
DIAGNOSIS AND MANAGEMENT OF
INFECTIOUS ENDOCARDITIS:
THE IMPACT OF MULTIDISCIPLINARY CARE
TEAMS

Sami El-Dalati, MD
Director, Endovascular Infections Service
Division of Infectious Diseases
University of Pittsburgh Medical Center
12/11/2020

Disclosures

- None

Objectives

- Defining endocarditis
- Overview of diagnosis and management
- Pitfalls of standard diagnostic criteria and algorithms
- Discussing the role of multidisciplinary endocarditis teams

Definition

- **Infective endocarditis (IE)** is an infection involving the endocardial surface of the heart, including the valvular structures, the chordae tendineae, sites of septal defects, or the mural endocardium.

Epidemiology - Infective Endocarditis

- ~43,000 cases per year in the U.S
- In hospital mortality 15-20%
- Lack of randomized controlled trials complicates patient management

Case Presentation

75 Year Old Male

- History of bioprosthetic aortic valve replacement for aortic stenosis
- Undergoes dental filling of lower wisdom teeth without antibiotic prophylaxis
- 4 days later develops fevers, dizziness and gait instability

75 Year Old Male

- On arrival to the ED is febrile to 101, WBC of 12
- MRI brain shows multifocal punctate lesions in multiple vascular territories concerning for septic emboli
- Blood cultures x3 obtained...negative
- TEE...negative for vegetation

Does he have endocarditis?

Diagnosis

- Modified Duke Criteria (2000)
 - Major

Diagnosis

- Modified Duke Criteria (2000)
 - Major
 - Microbiology
 - Typical microorganisms consistent with IE from 2 separate blood cultures
 - Single positive blood culture for *Coxiella burnetii* or antiphase I IgG antibody titer >1:800.

Diagnosis

- Modified Duke Criteria (2000)

- Major

- Microbiology

- Typical microorganisms consistent with IE from 2 separate blood cultures
 - Single positive blood culture for *Coxiella burnetii* or antiphase I IgG antibody titer >1:800.

- Endocardial involvement

- Echocardiogram positive for IE
 - Oscillating intracardiac mass, on valve or supporting structures, or in the path of regurgitant jets, or on implanted material,
 - Myocardial Abscess
 - New partial dehiscence of prosthetic valve
 - New valvular regurgitation.

Typical IE Microorganisms

Typical IE Microorganisms

- *Staphylococcus aureus*
- Viridans streptococci
- *Streptococcus Bovis*
- Community Acquired Enterococci without a source
- HACEK group (*Haemophilus, Aggregatibacter, Cardiobacterium, Eikenllea, Kingella* spp.)

Duke Criteria

- Minor Criteria

Duke Criteria

- **Minor Criteria**

- Fever >38 C (100.4 F)
- Predisposing heart condition or IV Drug Use
- Vascular phenomenon
 - Major arterial emboli, septic pulmonary infarcts, mycotic aneurysm, intracranial hemorrhage, conjunctival hemorrhage, Janeway lesions
- Immunologic phenomenon
 - Glomerulonephritis, Osler's nodes, Roth spots, presence of rheumatoid factor
- Positive blood culture not meeting major criterion

Duke Criteria

- Definite Endocarditis
- Possible Endocarditis

Duke Criteria

- **Definite Endocarditis**
 - 2 major criteria
 - 1 major criteria and 3 minor
 - 5 minor criteria
- **Possible Endocarditis**

Duke Criteria

- **Definite Endocarditis**
 - 2 major criteria
 - 1 major criteria and 3 minor
 - 5 minor criteria
- **Possible Endocarditis**
 - 1 major criteria, 1-2 minor
 - 3-4 minor criteria

Michigan Medicine Protocol

Clinical Features Increasing Suspicion for Infectious Endocarditis (IE)

- Fever (90% of patients)
- Heart Murmur (85% of patients)
- Systemic symptoms (anorexia, weight loss, night sweats)
- New stroke/neurologic deficits
- New bundle branch block
- New AV block of any degree
- New glomerulonephritis
- Cutaneous features of emboli/immunologic phenomenon
 1. Splinter hemorrhages
 2. Janeway lesions
 3. Osler's nodes)

Michigan Medicine Protocol

When to Evaluate a Patient for Infectious Endocarditis

Any patient for whom the provider has clinical
suspicion for IE

Any patient that has ≥ 2 clinical features


Any patient with a typical organism (see above)

Duke Criteria

- Minor Criteria
 - Fever >38 C (100.4 F)
 - **Predisposing heart condition or IV drug Use**
 - Vascular phenomenon
 - Major arterial emboli, septic pulmonary infarcts, mycotic aneurysm, intracranial hemorrhage, conjunctival hemorrhage, Janeway lesions
 - Immunologic phenomenon
 - Glomerulonephritis, Osler's nodes, Roth spots, rheumatoid factor
 - Positive blood culture not meeting major criterion

Infective Endocarditis: How Do We Currently Interpret the Duke Minor Criterion “Predisposing Heart Condition” in Native Valves?

Annina Elisabeth Büchi · Mario Hoffmann · Stephan Zbinden ·

Parham Sendi 

- Survey of 318 Swiss Physicians
 - 73.4% believed the Duke Criteria defined “Predisposing Heart Condition”

Predisposing Cardiac Conditions

- 2007 - Prevention of Infective Endocarditis Guidelines From the American Heart Association
 - Antibiotic Prophylaxis for:
 - Unrepaired cyanotic congenital heart disease
 - Recently repaired cyanotic heart disease with prosthetic material in the last 6 months
 - Repaired cyanotic heart disease with prosthetic material and residual shunt
 - Prosthetic valves
 - Previous IE
 - Transplanted heart with valvulopathy

Incidence of Infective Endocarditis in Patients With Bicuspid Aortic Valves in the Community



Hector I. Michelena, MD, Ognjen Katan, MD, Rakesh M. Suri, MD, DPhil, Larry M. Baddour, MD, Maurice Enriquez-Sarano, MD

Mayo Clinic, Rochester, MN

- Bicuspid Aortic Valve (BAV)
 - 416 patients with BAV in Olmsted County, MN from 1980 – 1999
 - Relative risk of IE in native BAV was 16.9 (P <0.0001)

Incidence and Predictors of Infective Endocarditis in Mitral Valve Prolapse

A Population-Based Study

Ognjen Katan, MD, Hector I. Michelena, MD  , Jean-Francois Avierinos, MD, Douglas W. Mahoney, MSc, Daniel C. DeSimone, MD, Larry M. Baddour, MD, Rakesh M. Suri, MD, DPhil, Maurice Enriquez-Sarano, MD

- Mitral Valve Prolapse
 - 896 Olmsted County, MN residents with MVP from 1986 - 2006
 - Relative Risk of IE of 8.1 (P<0.001)
 - Highest risk in MVP with moderate, moderate-severe or severe mitral regurgitation

Original Contribution

June 22/29, 2005

Staphylococcus aureus Endocarditis A Consequence of Medical Progress

Vance G. Fowler, MD, MHS; Jose M. Miro, MD, PhD; Bruno Hoen, MD, PhD; et al

Article Information

JAMA. 2005;293(24):3012-3021. doi:10.1001/jama.293.24.3012

- 558 patients with Staph Aureus IE
 - 23.1% had an intra-cardiac device (PPM, ICD, prosthetic valve)

Michigan Medicine Protocol

Risk factors for Infectious Endocarditis

- Prior IE
- Intravenous drug use (IVDU)
- Prosthetic valve
- Implantable cardiac device
- Indwelling central venous access
- Hemodialysis patients
- Poor dentition
- Bicuspid aortic valve
- Transplanted heart with valvulopathy
- Unrepaired cyanotic congenital heart disease or recently repaired with prosthetic material in the last 6 months or repaired cyanotic heart disease with prosthetic material and residual shunt

How sensitive/specific are
the Duke Criteria?

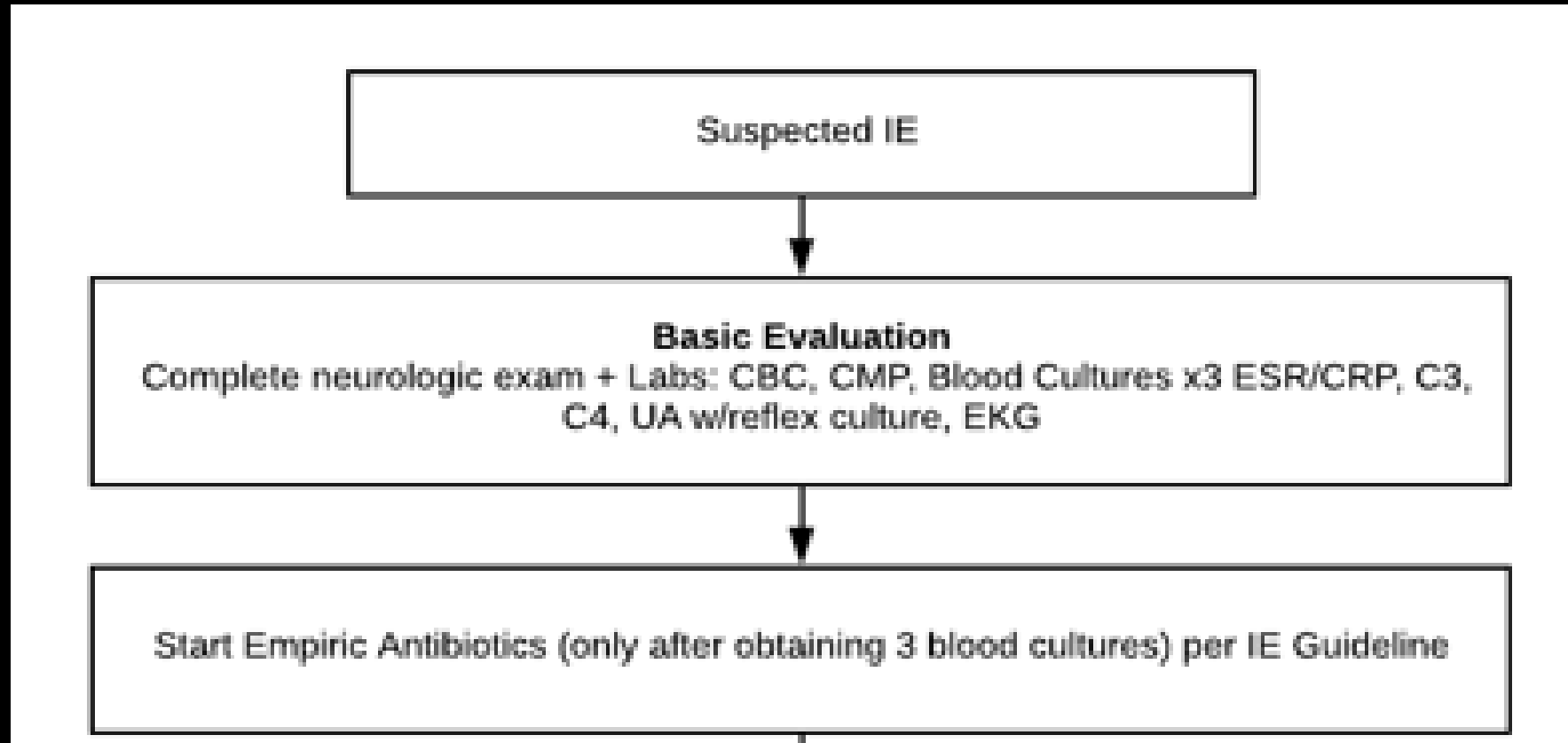
Duke Criteria

Study	Pathologically proven IE, N	Definite IE by Duke Criteria, n	Sensitivity (Percent, 95% CI)
Durack D et al, Am J Med 1994	69	55	78 (69 – 88)
Olaison L et al, Scand J Infect Dis 1996	44	32	73 (58 – 84)
Cechi E et al, Eur Heart J 1997	28	22	79 (60 – 90)
Heiro M et al, Arch Intern Med 1998	64	46	72 (60 – 81)
Habib G et al, JACC 1999	93	71	76 (67 – 84)

Duke Criteria

- Cleveland Clinic
- 532 episodes of suspected IE, surgically treated, between 2011 – 2014
 - 494 IE (pathologically proven)
 - 38 not IE (histopathology neg AND blood cultures neg AND valve PCR neg AND valve cultures neg)
- Sensitivity: 70% (95% C.I. 66 - 74%)
- Specificity: 74% (95% C.I. 57 - 87%)

MM Protocol - Initial Work-Up



Blood Cultures



Journal of
Clinical Microbiology

Bacteriology

Detection of Bloodstream Infections in Adults: How Many Blood Cultures Are Needed?

629 unimicrobial episodes with ≥ 3 blood cultures obtained during the 24-h period, 460 (73.1%) were detected with the first blood culture, 564 (89.7%) were detected with the first two blood cultures, 618 (98.2%) were detected with the first three blood cultures, and 628 (99.8%) were

Echocardiography

- Sensitivity for the diagnosis of vegetations?
- Specificity?

Echocardiography

- Sensitivity for the diagnosis of vegetations
 - TTE
 - Native valves ~70%
 - Prosthetic valves ~50%

Echocardiography

- Sensitivity for the diagnosis of vegetations
 - TTE
 - Native valves ~70%
 - Prosthetic valves ~50%
 - TEE
 - Native valves 96%
 - Prosthetic valves 92%

Echocardiography

- Sensitivity for the diagnosis of vegetations
 - TTE
 - Native valves ~70%
 - Prosthetic valves ~50%
 - TEE
 - Native valves 96%
 - Prosthetic valves 92%
- Specificity
 - ~90% for both TTE and TEE

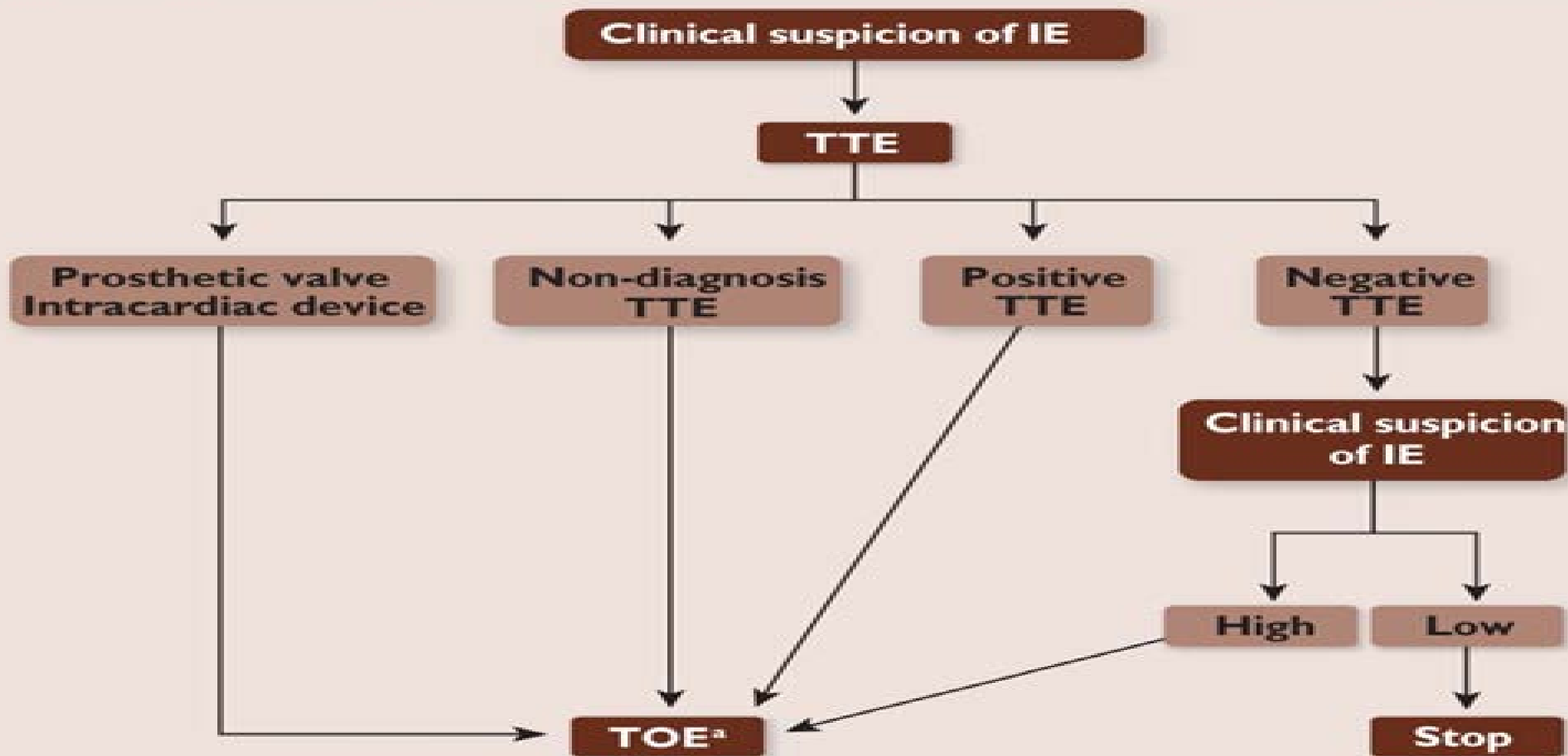
TEE

Eur Heart J. 1988 Jan;9(1):43-53.

Improved diagnostic value of echocardiography in patients with infective endocarditis by transoesophageal approach. A prospective study.

Erbel R¹, Rohmann S, Drexler M, Mohr-Kahaly S, Gerharz CD, Iversen S, Oelert H, Meyer J.

- 1988 Study
 - 96 Endocarditis Patients and identifiable vegetations on echocardiography
 - Only 20 patients had surgery
 - Reported 100% sensitivity of TEE



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

Echocardiography

Pettersson et al

Acquired

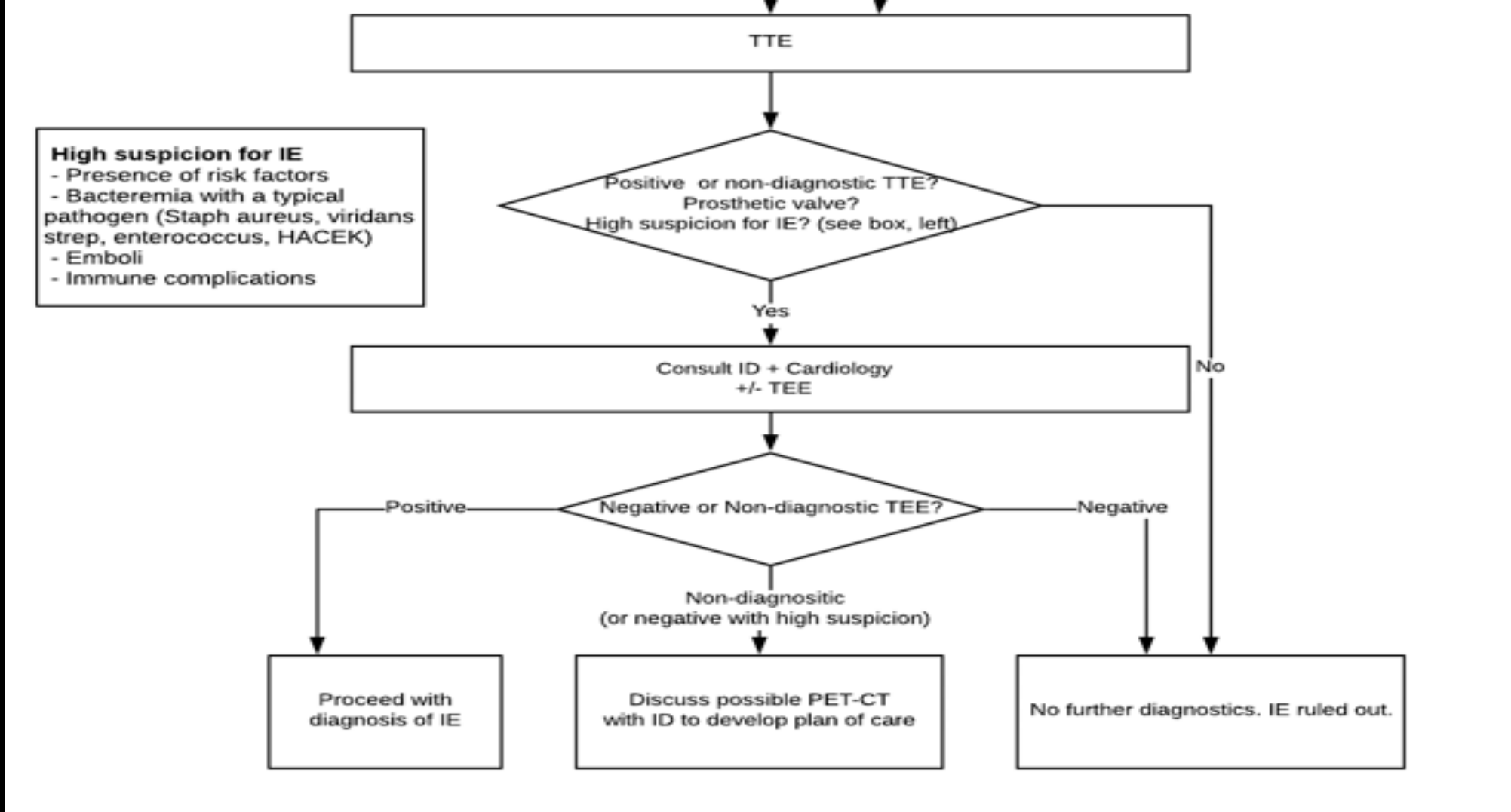
**2016 The American Association for Thoracic Surgery (AATS)
consensus guidelines: Surgical treatment of infective
endocarditis: Executive summary**

J Thorac Cardiovasc Surg 2017; ■:1-18

Standardized approach to define pathology:

- Invasive Disease: when tissue disintegration involve the valve annulus and infection invades extracellular areas
- Stages of Invasion: cellulitis, abscess, abscess cavity, pseudoaneurysm

MM Protocol - Echocardiography



Case Presentation

75 Year Old Male

- Culture negative endocarditis work-up is negative
- Cardiac PET
 - Focus of intense FDG uptake in the anterolateral aspect of the mitral annulus concerning for active infection or inflammation

PET-CT

ORIGINAL ARTICLE

Improving the Diagnosis of Infective Endocarditis in Prosthetic Valves and Intracardiac Devices with ^{18}F -FDG-PET/CT-Angiography: Initial Results at an Infective Endocarditis Referral Center

María N. Pizzi, Albert Roque, Nuria Fernández-Hidalgo, Hug Cuéllar-Calabria, Ignacio Ferreira-González, Maria T. González-Alujas, Gerard Oristrell, Laura Gracia-Sánchez, Juan J. González, José Rodríguez-Palomares, Manuel Galiñanes, Olga Maisterra-Santos, David García-Dorado, Joan Castell-Conesa, Benito Almirante, Santiago Agudé-Bruix, Pilar Tornos

- 92 patients with definite prosthetic valve endocarditis
 - 76 underwent PET/CT-A
 - Increased sensitivity of Duke Criteria to 91%
 - 90.6% specificity

PET-CT

Clinical Infectious Diseases

MAJOR ARTICLE



The Role of ^{18}F -Fluorodeoxyglucose Positron Emission Tomography/Computed Tomography in the Diagnosis of Left-sided Endocarditis: Native vs Prosthetic Valves Endocarditis

Raphael Abegão de Camargo,¹ Marcio Sommer Bitencourt,^{2,3} José Claudio Meneghetti,⁴ Jose Soares Jr,⁴ Luis Fernando Tonello Gonçalves,⁴

Characteristics	n	SE, %
Native valves		
Admission echocardiography	115	70
PET/CT cardiovascular focal uptake	115	22
Admission mDC ^a	115	54
Admission mDC ^a + PET/CT major criteria	115	65
Admission mDC ^a + PET/CT major criteria + emboli ^b	115	78

2015 European Society of Cardiology Endocarditis Guideline

2. Imaging positive for IE

a. Echocardiogram positive for IE:

- Vegetation;
- Abscess, pseudoaneurysm, intracardiac fistula;
- Valvular perforation or aneurysm;
- New partial dehiscence of prosthetic valve.

b. Abnormal activity around the site of prosthetic valve implantation detected by ^{18}F -FDG PET/CT (only if the prosthesis was implanted for ≥ 3 months) or radiolabelled leukocytes SPECT/CT.

c. Definite paravalvular lesions by cardiac CT.

Should we screen asymptomatic patients for septic emboli?

Screening for Emboli?

Routine cerebral CT angiography in infective endocarditis: impact on treatment decision

M.S. Meshael, H. Kassem Heshmat, Y. Baghdady, A. Sameer, A. Zakaria, H.H. Rizk

European Heart Journal, Volume 34, Issue suppl_1, 1 August 2013, 5951,

<https://doi.org/10.1093/eurheartj/eh311.5951>

Published: 01 August 2013

- Prospective study
- 81 patients with definite IE, all had CT/CT-A brain within 2 weeks of diagnosis
- 51 (63%) had evidence of embolization – 17 of which were silent
- Prompted changes in management in 21% of cases

Screening for Emboli?

Annals of Internal Medicine®

LATEST

ISSUES

CHANNELS

CME/MOC

IN THE CLINIC

JOURNAL CLUB

WEB EXCLUSIVES

AUTHOR INFO

[< PREV ARTICLE](#) | [THIS ISSUE](#) | [NEXT ARTICLE >](#)

ORIGINAL RESEARCH | 20 APRIL 2010

Effect of Early Cerebral Magnetic Resonance Imaging on Clinical Decisions in Infective Endocarditis: A Prospective Study

Xavier Duval, MD, PhD; Bernard Iung, MD; Isabelle Klein, MD, PhD; Eric Brochet, MD; Gabriel Thabut, MD, PhD; Florence Arnoult, MD; Laurent Lepage, MD; Jean-Pierre Laissy, MD, PhD; Michel Wolff, MD; Catherine Leport, MD, PhD; IMAGE (Resonance Magnetic Imaging at the Acute Phase of Endocarditis) Study Group

- 130 patients with endocarditis, all had MRI/A of the brain within 7 days of admission
 - Only 12% had neurologic symptoms
 - 82% had “cerebral lesions”
 - 32% of non-definite cases of endocarditis were upgraded to “possible” or “definite”
 - Led to modification of therapeutic plan in 28%

Screening for Emboli?

Respective effects of early cerebral and abdominal magnetic resonance imaging on clinical decisions in infective endocarditis FREE

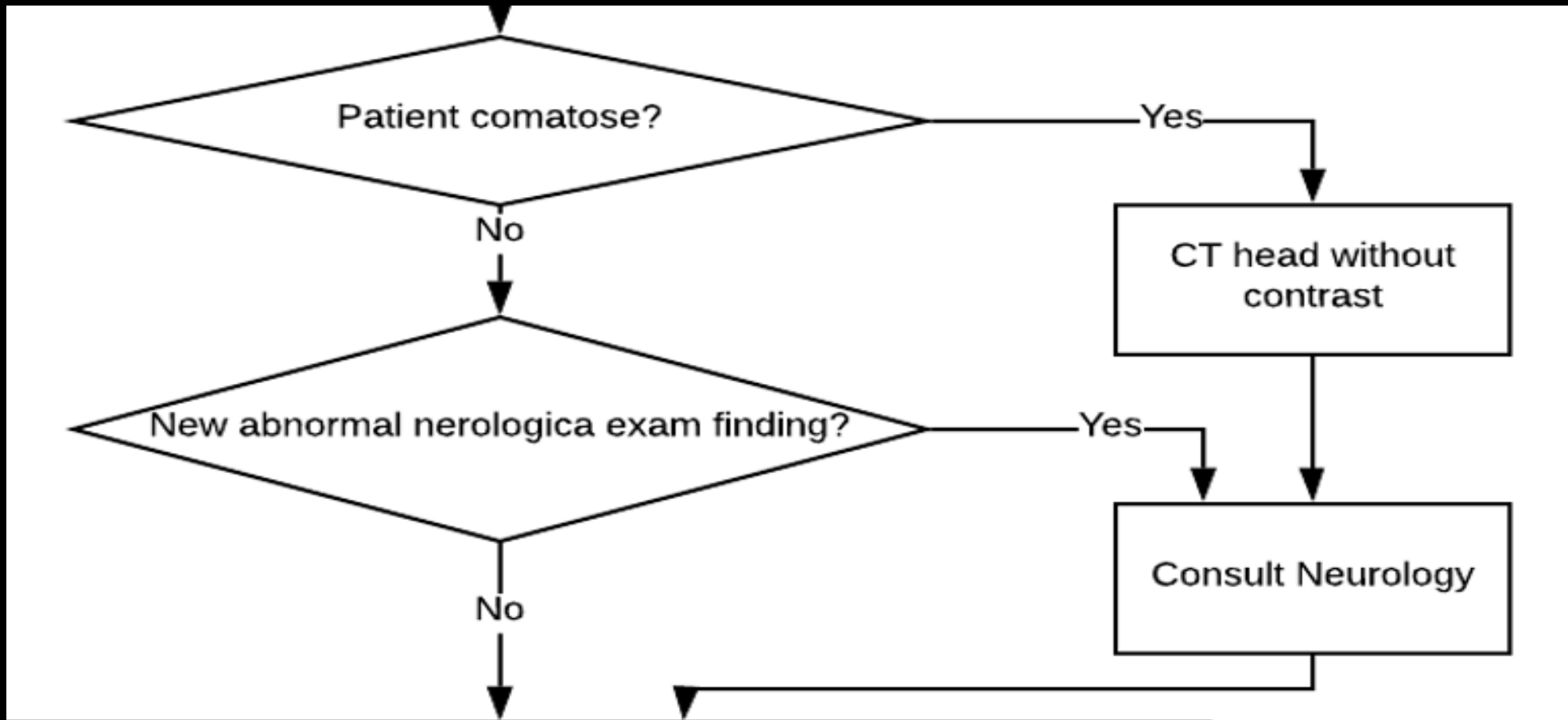
Bernard Lung ✉, Isabelle Klein, Bruno Mourvillier, Jean-Marc Olivot, Delphine Détaint, Pascale Longuet, Raymond Ruimy, Dominique Fourchy, Jean-Jacques Laurichesse, Jean-Pierre Laissy ... [Show more](#)

European Heart Journal - Cardiovascular Imaging, Volume 13, Issue 8, 1 August 2012, Pages 703–710, <https://doi.org/10.1093/ehjci/jes023>

Published: 14 February 2012 **Article history** ▼

- Prospective study of 58 patients who underwent MRI Brain and Abdomen within 7 days of admission
- Abdominal MRI by itself did not lead to upgrades in diagnosis or changes in management plan

MM Protocol – Screening for Emboli



Should we be looking for a
source?

Portal of Entry

Journal of the American College of Cardiology

Volume 67, Issue 2, January 2016

DOI: 10.1016/j.jacc.2015.10.065



Systematic Search for Present and Potential Portals of Entry for Infective Endocarditis

François Delahaye, Ali M'Hammedi, Brice Guerpillon, Guy de Gevigney, André Boibieux, Olivier Dauwalder, Coralie Bouchiat and François Vandenesch

- All patients had CT head/chest/abdomen/pelvis
- All patients were seen by Dentist/ENT/Urologist
- Women seen by Gynecologist
- Patients with organisms from GI tract or age >50 underwent colonoscopy
- 238/314 patients (74%) found to have potential portals of entry for IE

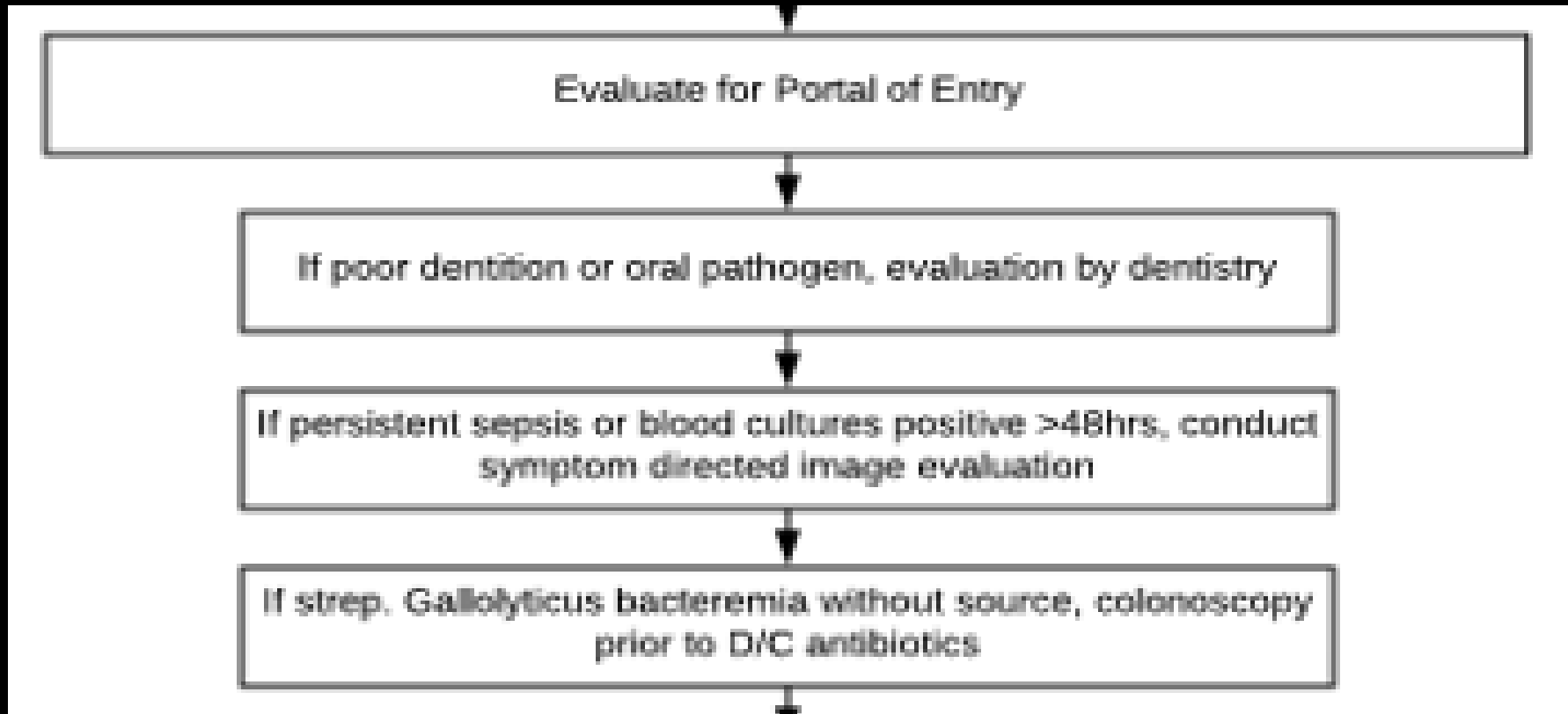
Portal of Entry

Portal of Entry	
Cutaneous	96 (40)
Intravenous drug use	21
Nonintravenous drug use	75
Oral/dental	68 (29)
Gastrointestinal	56 (23)
Genitourinary	10 (4)
Ear, nose, and throat	5 (2)
Respiratory	3 (1)
Total	238 (100)

Values are n (%) or n.

Lower gastrointestinal tract	51 (91)
Polyps	22 (39)
Unique, ≥ 1 cm	7 (12)
Multiple, ≥ 1 cm	5 (9)
Multiple, < 1 cm	4 (7)
Multiple, size unknown	6 (11)
Colorectal adenocarcinoma	8 (14)
Sigmoid diverticulosis	11 (20)

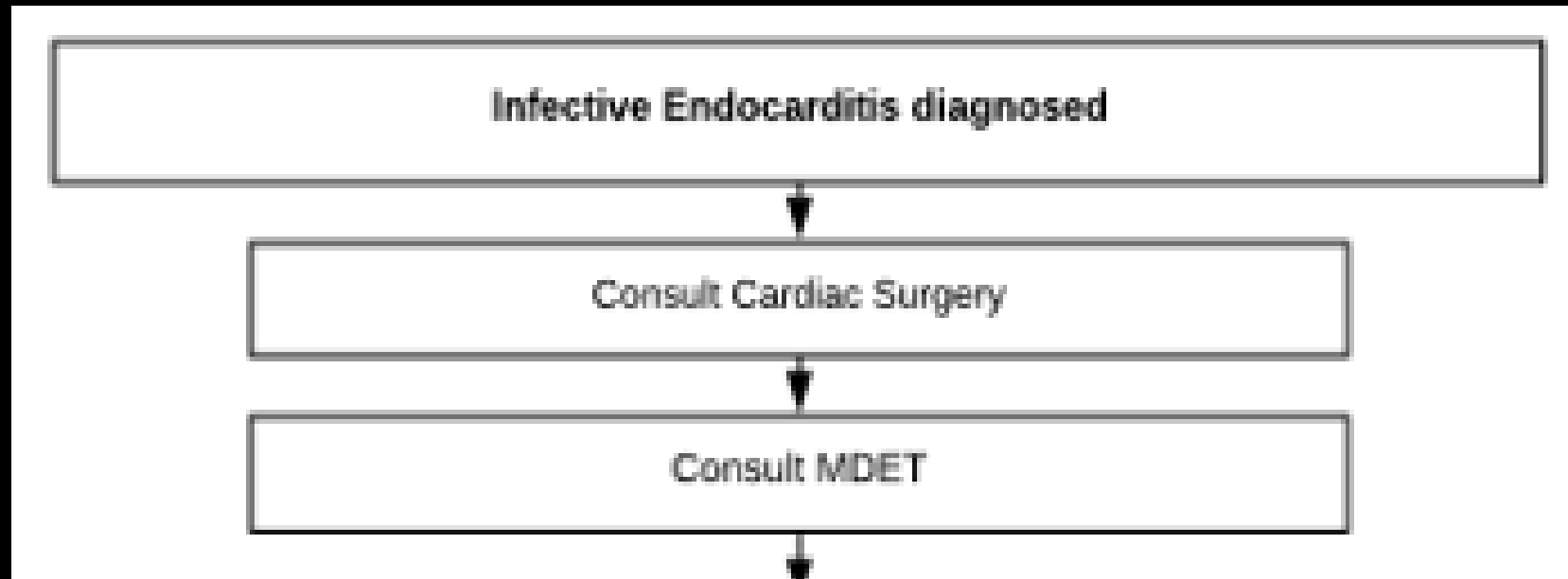
MM Protocol - Portal of Entry



Management

- North American Guidelines
 - 2015 IDSA and AHA Guidelines
- 2015 European Society of Cardiology Guidelines

MM Protocol - Management



Surgical Indications

- AHA Guidelines

- Class I Indications

- Valve dysfunction resulting in symptoms or signs of heart failure.
 - IE caused by fungal or highly resistant organisms (eg, vancomycin-resistant Enterococcus, multidrug-resistant Gram-negative bacilli)
 - IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions
 - Evidence of persistent infection (manifested by persistent bacteremia or fever lasting >5-7 days and provided that other sites of infection and fever have been excluded) after the start of appropriate antimicrobial therapy

Surgical Indications

- **AHA Guideline**

- Class IIa indications

- Recurrent emboli and persistent or enlarging vegetations despite appropriate antibiotic therapy
 - Severe valve regurgitation and mobile vegetations >10 mm

- Class IIb indication

- Mobile vegetations >10 mm, particularly when involving the anterior leaflet of the mitral valve and associated with other relative indications for surgery

Risk of Emboli

Journal of the American College of Cardiology

Volume 62, Issue 15, October 2013

DOI: 10.1016/j.jacc.2013.07.029

 PDF Article

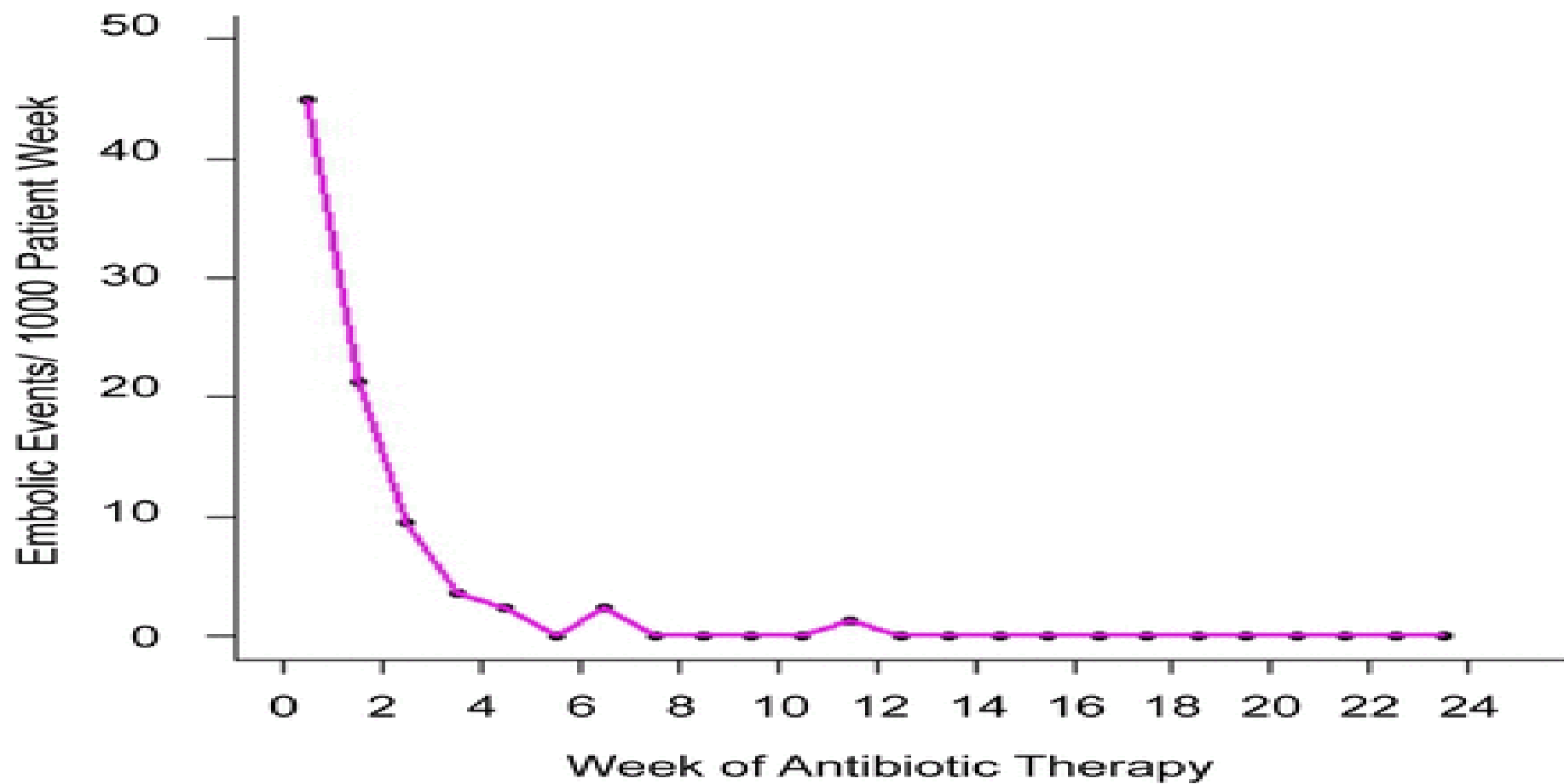
Prediction of Symptomatic Embolism in Infective Endocarditis

Construction and Validation of a Risk Calculator in a Multicenter Cohort

Sandrine Hubert, Franck Thuny, Noemie Resseguier, Roch Giorgi, Christophe Tribouilloy, Yvan Le Dolley, Jean-Paul Casalta, Alberto Riberi, Florent Chevalier, Dan Rusinaru, Dorothee Malaquin, Jean Paul Remadi, Ammar Ben Ammar, Jean Francois Avierinos, Frederic Collart, Didier Raoult and Gilbert Habib

- 847 patients in multi-center retrospective study
- Emboli in 8.5% of patients at median time of 6.5 days after initiation of antibiotics
- Highest incidence in first two weeks
 - 44.9 per 1000 patient weeks in 1st week
 - 21.3 per 1000 patient weeks in 2nd week
 - 2.4 per 1000 patient weeks after 2nd week

Risk of Emboli



Risk of Emboli

- Factors contributing to risk of embolism
 - Increasing age
 - Diabetes
 - Atrial fibrillation
 - Embolism before antibiotics
 - Vegetation length >10 mm
 - Staphylococcus aureus infection

DATA AT ADMISSION		
Clinical Data	Age (years)	75
	Diabetes (0: no ; 1: yes)	1
	Previous embolism (0: no ; 1: yes)	1
	Atrial fibrillation (0: no ; 1: yes)	0
Echocardiography	Vegetation >0 to ≤10 mm (0: no ; 1: yes)	0
	Vegetation >10 mm (0: no ; 1: yes)	1
Microorganism	<i>Staphylococcus aureus</i> (0: no ; 1: yes)	1

PREDICTED EMBOLIC RISK CALCULATION		
Time (Days)	Predicted Embolic Risk	
1		5%
2		6%
3		10%
4		13%
5		14%
6		15%
7		16%
10		18%
11		18%
12		20%
13		22%
14		24%
18		24%
19		25%
23		26%
28		27%
35		27%
47		28%
48		28%
180		29%

Timing of Surgery After Stroke

Stroke is not a Contraindication for Urgent Valve Replacement in Acute Infective Endocarditis


Cornelia Piper MD, Marcus Wiemer MD, Hagen D. Schulte MD, Dieter Horstkotte MD

- 2001 Retrospective Study
 - 288 patients from 1978-1993

The prognosis for patients who had surgery within 72 h after stroke was significantly more favorable ($p < 0.0001$) than for those not treated surgically or operated on > 8 days after the event. The risk of a secondary cerebral hemorrhage during this period (< 72 h) appears to be low, if early reperfusion hemorrhage is excluded by perioperative cranial computed tomography.

Timing of Surgery After Stroke

Influence of the Timing of Cardiac Surgery on the Outcome of Patients With Infective Endocarditis and Stroke FREE

Bruno Barsic , Stuart Dickerman, Vladimir Krajinovic, Paul Pappas, Javier Altclas, Giampiero Carosi, José H. Casabé, Vivian H. Chu, Francois Delahaye, Jameela Edathodu ... [Show more](#)

Clinical Infectious Diseases, Volume 56, Issue 2, 15 January 2013, Pages 209–217,

- International Collaboration on Endocarditis (ICE)
 - 198 Patients with stroke who underwent surgery
 - No in-hospital or 1-year mortality benefit to delaying surgery after stroke

Association Between Surgical Indications, Operative Risk, and Clinical Outcome in Infective Endocarditis

A Prospective Study From the International Collaboration on Endocarditis

Vivian H. Chu, Lawrence P. Park, Eugene Athan, Francois Delahaye, Tomas Freiburger, Cristiane Lamas, Jose M. Miro, Daniel W. Mudrick, Jacob Strahilevitz, Christophe Tribouilloy, Emanuele Durante-Mangoni, Juan M. Pericas, Nuria Fernández-Hidalgo, Francisco Nacinovich, Hussien Rizk, Vladimir Krajinovic, Efthymia Giannitsioti, John P. Hurley, Margaret M. Hannan, Andrew Wang
and for the International Collaboration on Endocarditis (ICE) Investigators*

- Surgery during the index hospitalization is associated with lower mortality but is performed less frequently in the highest risk patients.
- **One-quarter of left-sided IE cases with indications for surgery did not undergo surgery** due to operative risk factors, such as sepsis, but **surgery was associated with a survival benefit after adjustment for operative risk.**

Neurological complication

- Clinical assessment
- Cerebral CT scan / MRI
- TTE / TOE

- Heart failure
- Uncontrolled infection
- Abscess
- High embolic risk

Yes

- Intracranial haemorrhage
- Coma
- Severe comorbidities
- Stroke with severe damage

No

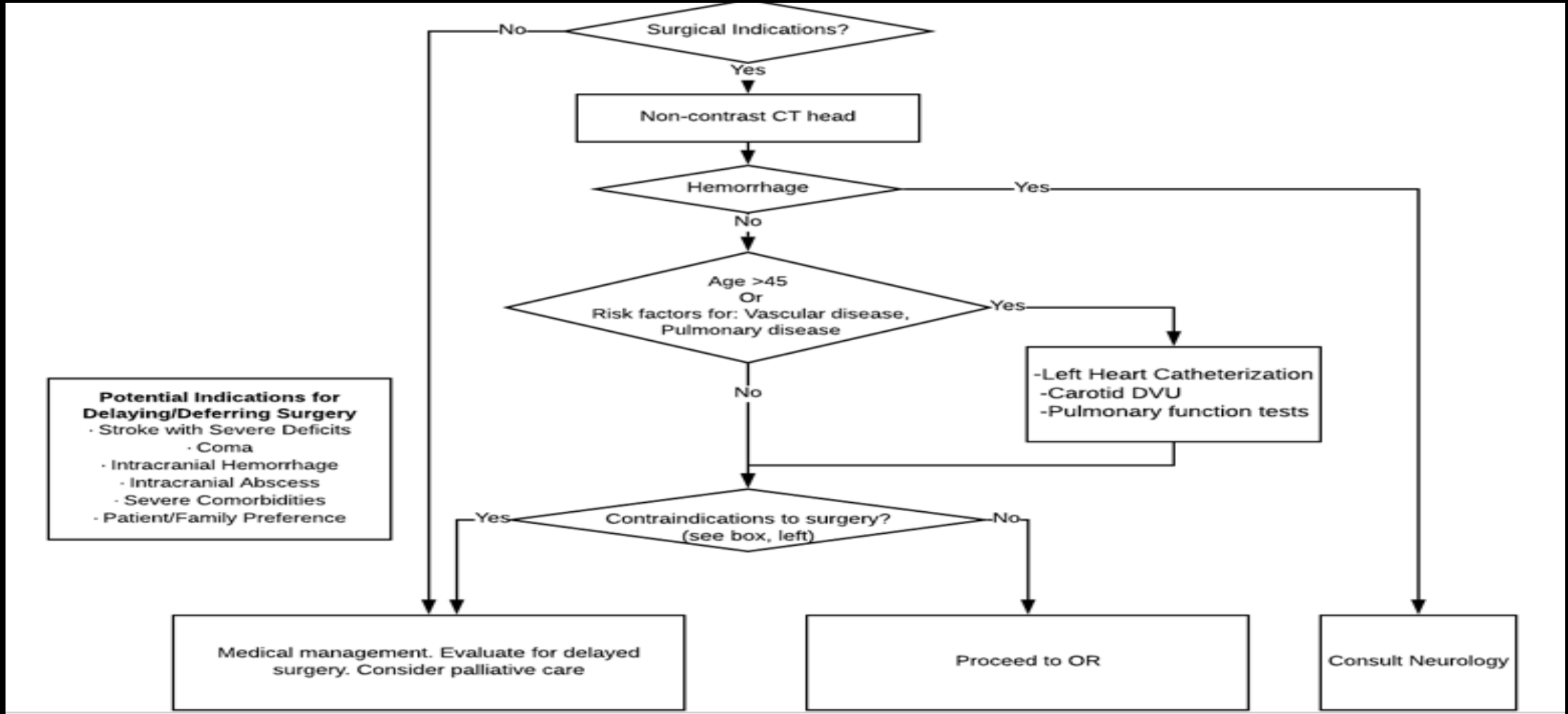
Consider surgery
(see Table 22)

Yes

No

Conservative treatment
and monitoring

MM Protocol – Surgery



Infective Endocarditis at Michigan Medicine

Infective Endocarditis at Michigan Medicine

- Previous Management Model



Infective Endocarditis at Michigan Medicine

- No existing registry or database of patients
- How do our outcomes compare to national numbers?
- How frequently do we operate on patients?
- Mortality for surgical vs. medical management?
- Is there consistent documentation regarding decision making process?

Infective Endocarditis at Michigan Medicine

- 1-year retrospective review of patients admitted with IE
- Charts identified by search using an internal research tool (Data Direct) with ICD-9 and 10 codes previously used in other epidemiologic studies

Infective Endocarditis at Michigan Medicine

- Between July 1, 2014 and June 30, 2015
 - 179 patients identified
 - 105 cases of definite and possible endocarditis by Duke Criteria
 - 78 cases of definite endocarditis
 - 68 cases of definite endocarditis AND at least 1 indication for surgery per the 2015 American Heart Association guidelines

Surgical Indications

- AHA Guidelines

- Class I Indications

- Valve dysfunction resulting in symptoms or signs of heart failure
 - IE caused by fungal or highly resistant organisms (eg, vancomycin-resistant Enterococcus, multidrug-resistant Gram-negative bacilli)
 - IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions
 - Evidence of persistent infection (manifested by persistent bacteremia or fever lasting >5-7 days and provided that other sites of infection and fever have been excluded) after the start of appropriate antimicrobial therapy

Surgical Indications

- **AHA Guidelines**

- Class IIa indications

- Recurrent emboli and persistent or enlarging vegetations despite appropriate antibiotic therapy
 - Severe valve regurgitation and mobile vegetations >10 mm

- Class IIb indication

- Mobile vegetations >10 mm, particularly when involving the anterior leaflet of the mitral valve and associated with other relative indications for surgery

Infective Endocarditis at Michigan Medicine

- 68 patients with definite endocarditis and surgical indications
 - Overall in-hospital mortality: 29.4%



Infective Endocarditis at Michigan Medicine

- 17 patients (25%) without a documented cardiac surgery consult
 - In-hospital mortality for these patients: 47.1%



Infective Endocarditis at Michigan Medicine

- 17 patients (25%) without a documented cardiac surgery consult
 - In-hospital mortality for these patients: 47.1%
- 51 patients with documented cardiac surgery consultation
 - 26 patients managed medically
 - In-hospital mortality: 38.5%, 2-year mortality 65.4%

Infective Endocarditis at Michigan Medicine

- 17 patients (25%) without a documented cardiac surgery consult
 - In-hospital mortality for these patients: 47.1%
- 51 patients with documented cardiac surgery consultation
 - 26 patients managed medically
 - In-hospital mortality: 38.5%, 2-year mortality 65.4%
 - 25 patients underwent surgery
 - In-hospital mortality: 8% ; $p = 0.01$, 2-year mortality 20% ; $p = 0.001$
 - Mean time to consult from admission: 7.1 days
 - Mean time to surgery from consult: 7.3 days

Differences Between Surgically and Medically Managed Patients

Variable	Surgical Management (n=25)	Medical Management (n=26)	P-Value
Acute HD (%)	0	26.9	0.006
ICU Stay (%)	24	53.8	0.03
Mitral Valve (%)	16	42.3	0.04
Staph Aureus Bacteremia (%)	8	34.6	0.02
>2 Indications for Surgery (%)	12	38.5	0.03
STS Risk of Mortality >8% (%)	28.6	60	0.03

Documented Reasons for Deferring Surgical Intervention

Reason for Deferring Surgery	Number of Cases (n = 26)
High Peri-Operative Mortality	13 (50%)
Continued IV Drug Use	5 (19.2%)
Not Clearly Stated	2 (7.7%)
Patient Co-morbidities	2 (7.7%)
TPN Dependence	1 (3.8%)
Illness Acuity	1 (3.8%)
Patient/Family Declined	1 (3.8%)
Deconditioning	1 (3.8%)

In-Hospital Outcomes for Critically Ill Patients

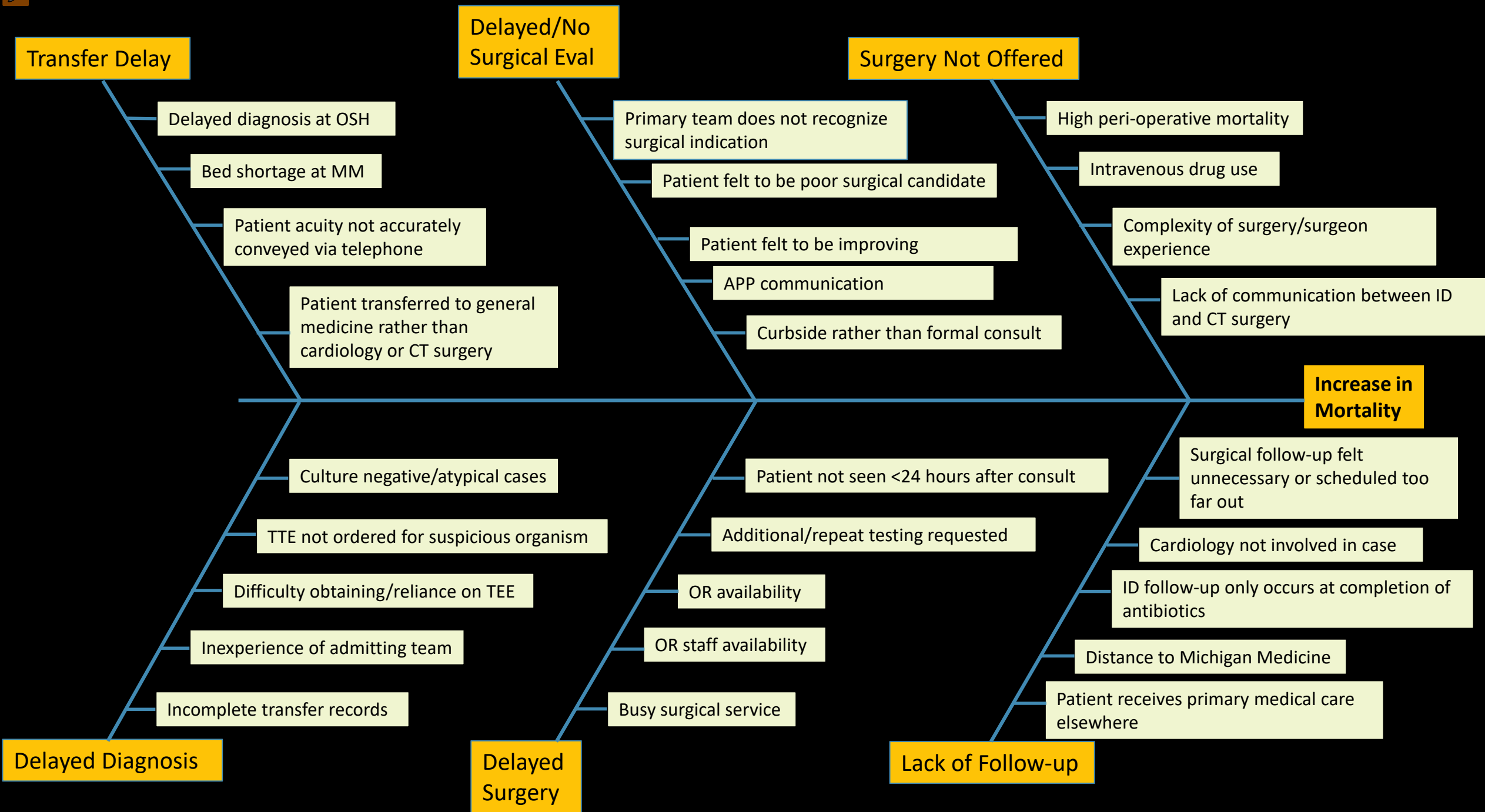
Variable	Mortality for Surgically Managed Patients (%)	Mortality for Medically Managed Patients (%)	P-Value
All Patients	8 (n =25)	38.5 (n =26)	0.01
STS Risk of Morality >8%	16.7 (n=6)	73.3 (n=15)	0.02
ICU Patients	0 (n = 6)	85.7 (n = 14)	0.02
Vasopressor Requirement	0 (n =5)	77.8 (n = 9)	0.003
Mechanical Ventilation	0 (n =4)	85.7 (n =7)	0.003
ICU/Vasopressors/Mechanical Ventilation	0 (n=4)	83.3 (n=6)	0.01

Summary

- In-hospital mortality and 2-year mortality was significantly improved for patients who underwent surgical valve replacement
- Critically ill patients are often not referred for or offered surgery but may still benefit from surgical intervention
- There is room for improving communication between providers
- There are likely other unidentified factors contributing to higher patient mortality



How can we do better?



Dramatic Reduction in Infective Endocarditis-Related Mortality With a Management-Based Approach

1992, implementation of specialized consultants

173 cases

160 cases

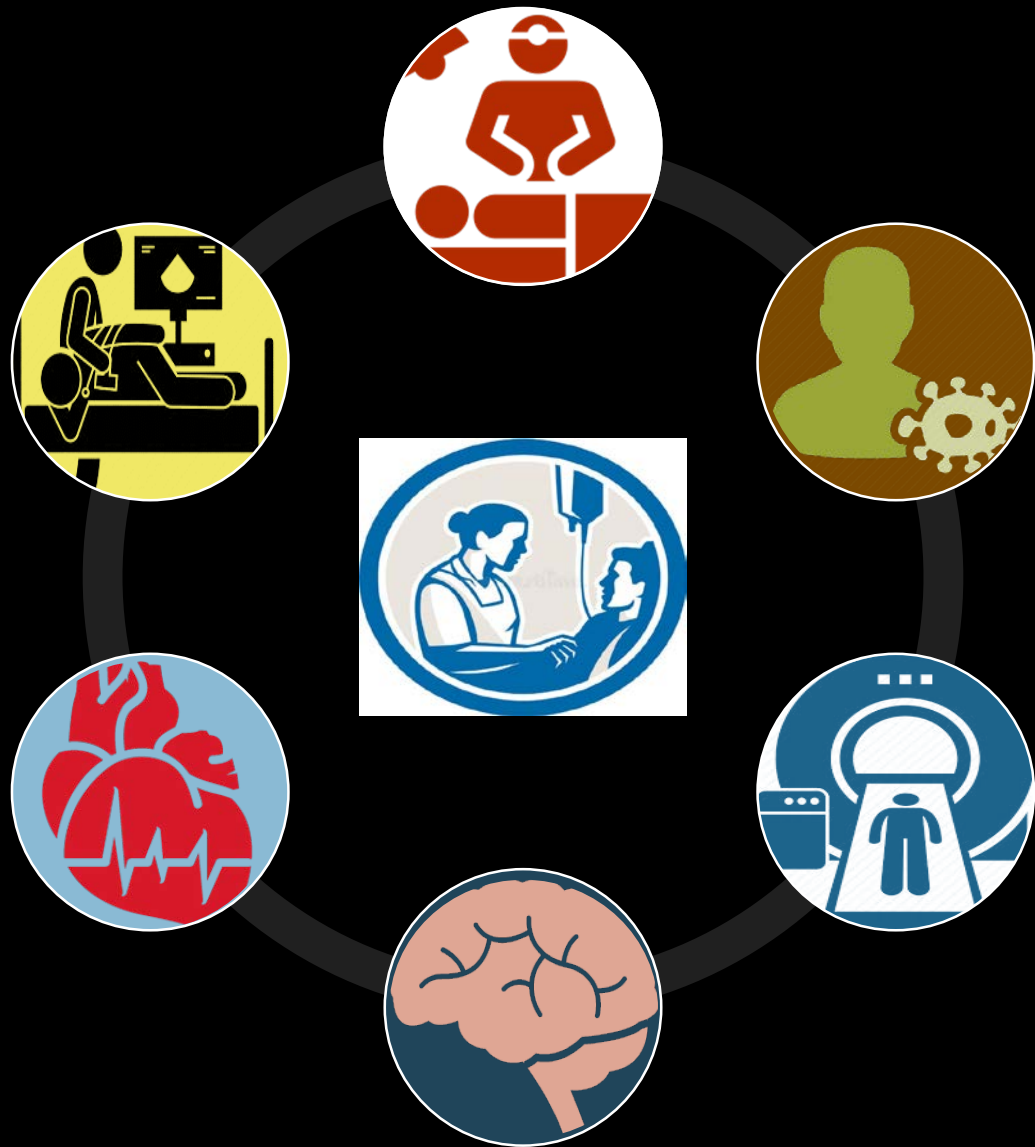
Mortality - 18.5%

Mortality - 8.2%

1991

2006

2002, implementation of endocarditis team & protocol



2015 ESC Endocarditis Guideline

Role of the 'Endocarditis Team'

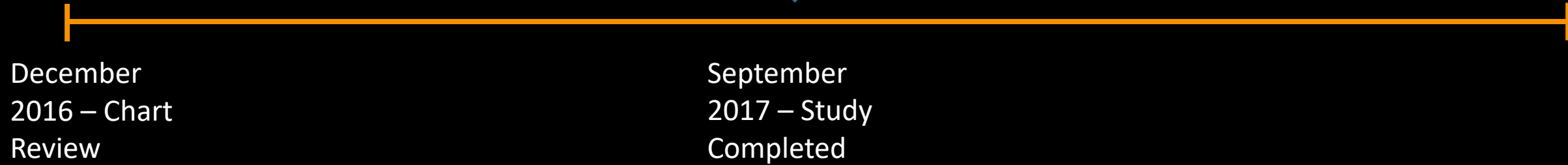
1. The 'Endocarditis Team' should have meetings on a regular basis in order to discuss cases, take surgical decisions, and define the type of follow-up.
2. The 'Endocarditis Team' chooses the type, duration, and mode of follow up of antibiotic therapy, according to a standardized protocol, following the current guidelines.
3. The 'Endocarditis Team' should participate in national or international registries, publicly report the mortality and morbidity of their centre, and be involved in a quality improvement programme, as well as in a patient education programme.
4. The follow-up should be organized on an outpatient visit basis at a frequency depending on the patient's clinical status (ideally at 1, 3, 6, and 12 months after hospital discharge, since the majority of events occur during this period⁵⁷).

Multidisciplinary Endocarditis Team



December
2016 – Chart
Review

Multidisciplinary Endocarditis Team



December
2016 – Chart
Review

September
2017 – Study
Completed

Multidisciplinary Endocarditis Team



Multidisciplinary Endocarditis Team



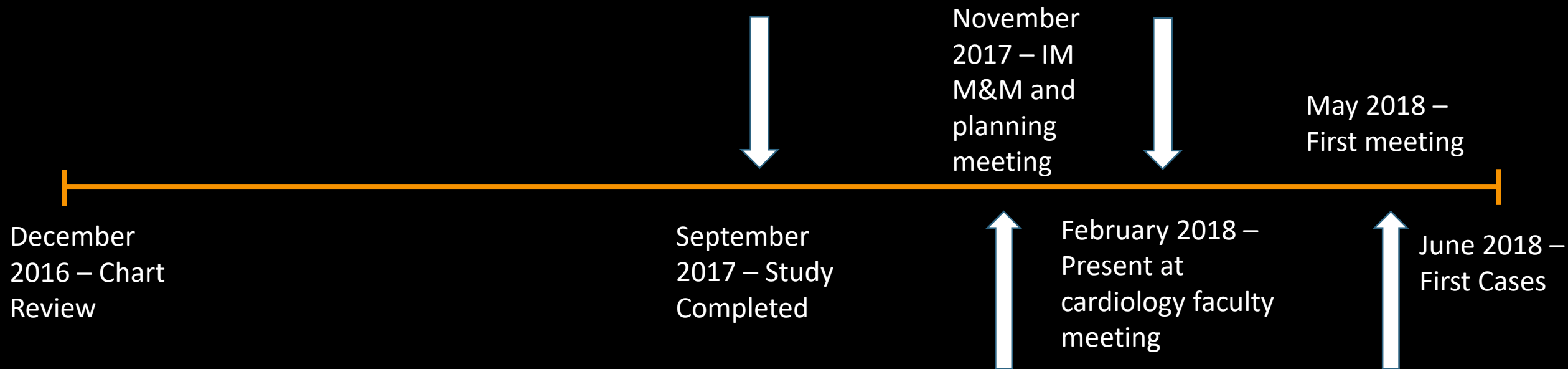
Multidisciplinary Endocarditis Team



Multidisciplinary Endocarditis Team



Multidisciplinary Endocarditis Team



Multidisciplinary Endocarditis Team

- Implemented June 14, 2018
 - 3 Infectious Diseases Specialists
 - 2 Cardiac Surgeons
 - 2 Cardiologists
 - 1 Stroke Neurologist
 - 1 Cardiac Surgery PA
 - 1 ID Pharmacist
 - Institutional Protocol Developed
 - Best Practice Advisory created in Epic encouraging cardiac surgery consultation for endocarditis patients



ENDOCARDITIS DIAGNOSTIC AND MANAGEMENT ALGORITHM

Clinical Features Increasing Suspicion for Infectious Endocarditis (IE)

- Fever (90% of patients)
- Heart Murmur (85% of patients)
- Systemic symptoms (anorexia, weight loss, night sweats)
- New stroke/neurologic deficits
- New bundle branch block
- New AV block of any degree
- New glomerulonephritis
- Cutaneous features of emboli/immunologic phenomenon
 1. Splinter hemorrhages
 2. Janeway lesions
 3. Osler's nodes

Consider Early Surgery in Patients with IE

Class I Indications

- Valve dysfunction resulting in symptoms or signs of heart failure.
- IE caused by fungal or highly resistant organisms (eg, vancomycin-resistant Enterococcus, multidrug-resistant Gram-negative bacilli)
- IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions
- Evidence of persistent infection (manifested by persistent bacteremia or fever lasting >5-7 days and provided that other sites of infection and fever have been excluded) after the start of appropriate antimicrobial therapy

Class IIa indications

- Recurrent emboli and persistent or enlarging vegetations despite appropriate antibiotic therapy
- Severe valve regurgitation and mobile vegetations >10 mm

Class IIb indications

- Mobile vegetations >10 mm, particularly when involving the anterior leaflet of the mitral valve and associated with other relative indications for surgery

Risk factors for Infectious Endocarditis

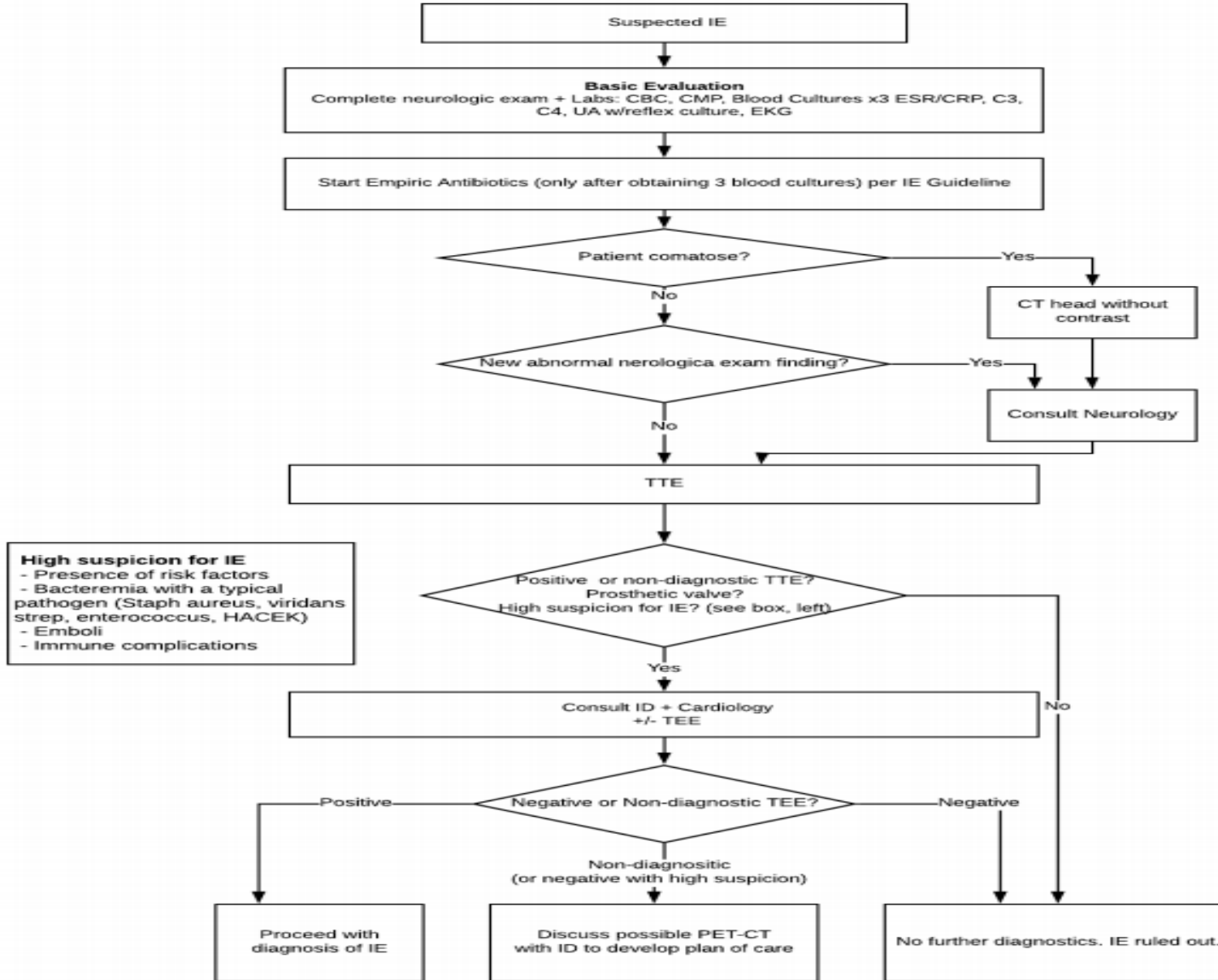
- Prior IE
- Intravenous drug use (IVDU)
- Prosthetic valve
- Implantable cardiac device
- Indwelling central venous access
- Hemodialysis patients
- Poor dentition
- Bicuspid aortic valve
- Transplanted heart with valvulopathy
- Unrepaired cyanotic congenital heart disease or recently repaired with prosthetic material in the last 6 months or repaired cyanotic heart disease with prosthetic material and residual shunt

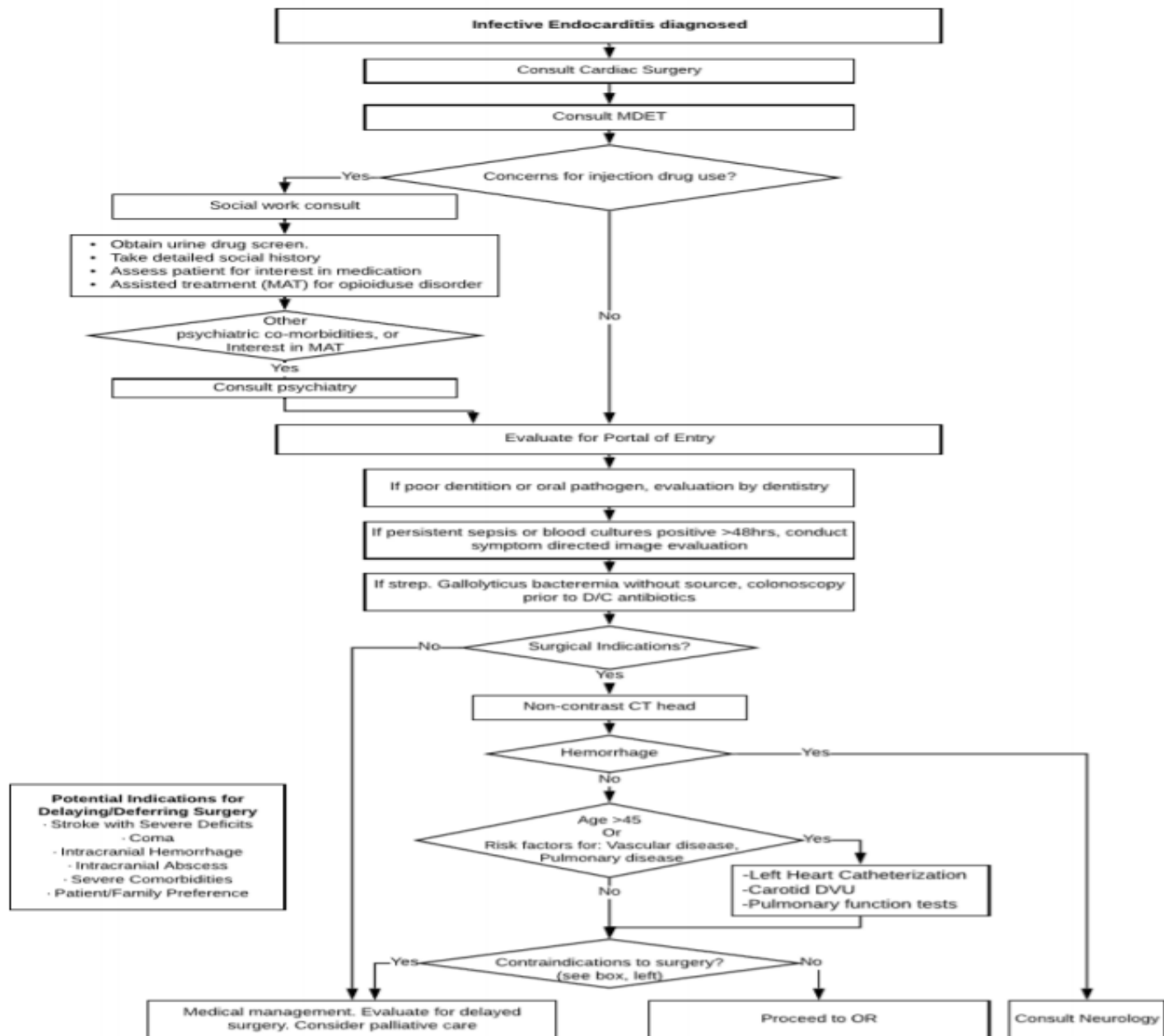
Typical Organisms in Native Valve IE

- Staph Aureus (both MSSA and MRSA)
- Enterococci
- Viridans Streptococci
- Streptococcus Gallolyticus
- HACEK Species

When to Evaluate a Patient for Infectious Endocarditis

- Any patient for whom the provider has clinical suspicion for IE
- Any patient that has ≥ 2 clinical features
- Any patient with a typical organism (see above)





Best Practice Advisory

Important (1)



This patient carries a diagnosis of endocarditis and/or an infectious disease consult has been placed for endocarditis. Retrospective data suggests that patients with endocarditis who receive documented cardiac surgical consultation have improved in-hospital mortality.

- ⓘ Please consider formally consulting cardiac surgery for assistance in management of this patient's infection.

A **Consult for Cardiac Surgery** order can be placed below by clicking "**Accept**".

Early surgery is recommended for:

- Patients with IE who present with valve dysfunction resulting in symptoms or signs of heart failure.
- Patients with IE caused by fungal or highly resistant organisms (e.g., vancomycin-resistant Enterococcus, multidrug-resistant Gram-negative bacilli)
- Patients with IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions
- Evidence of persistent infection (manifested by persistent bacteremia or fever lasting > 5-7 days and provided that other sites of infection and fever have been excluded) after the start of appropriate antimicrobial therapy
- Patients who present with recurrent emboli and persistent or enlarging vegetation despite appropriate antibiotic therapy
- Patients with severe valve regurgitation and mobile vegetation > 10 mm
- Prosthetic valve endocarditis

Order

Do Not Order



Consult to Cardiac Surgery Adult

Acknowledge Reason

Remind me in 24 hours

Patient does not have endocarditis

Patient is comfort care

Other (document as comments)

ID Consult Order

Consult to Infectious Disease ✓ Accept ✗ Cancel

Reason for Consult:

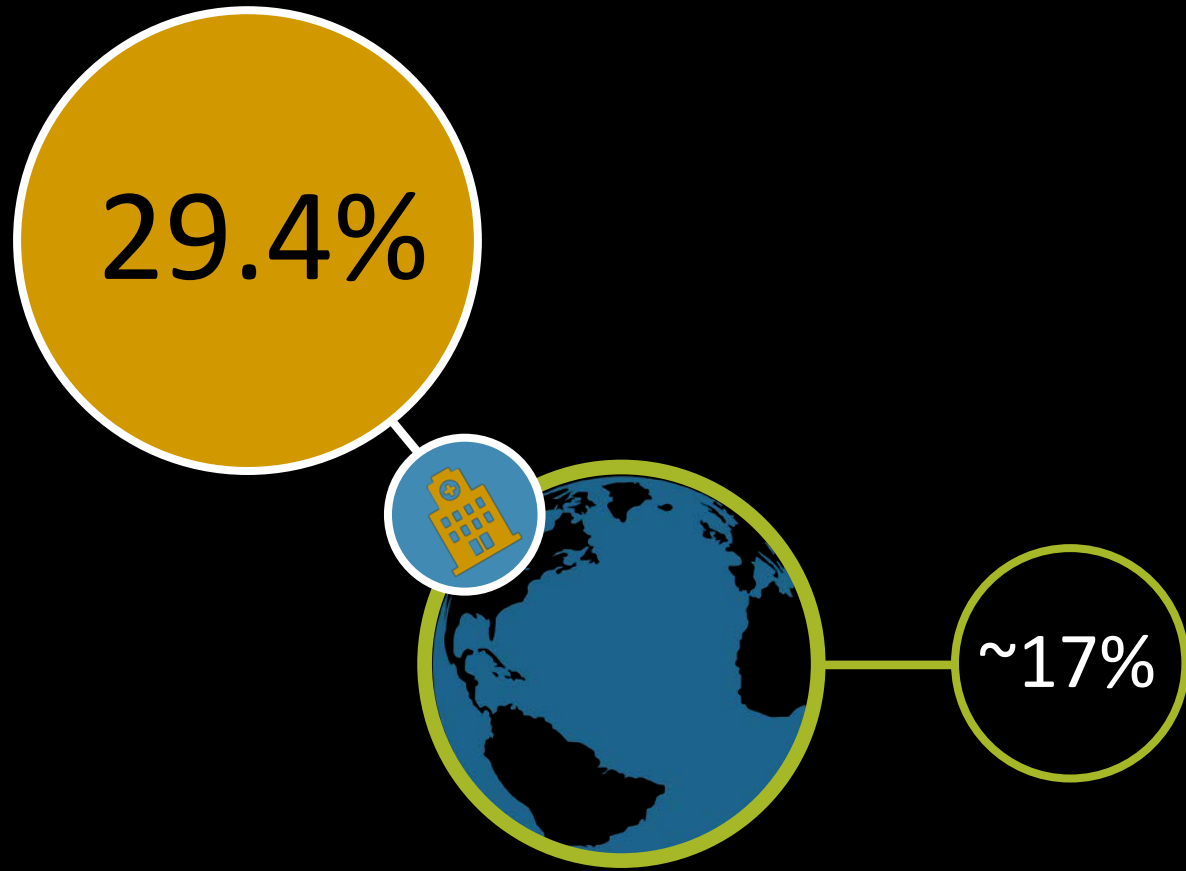
Solid organ transplant:

Bone marrow transplant:

Multidisciplinary Endocarditis Team

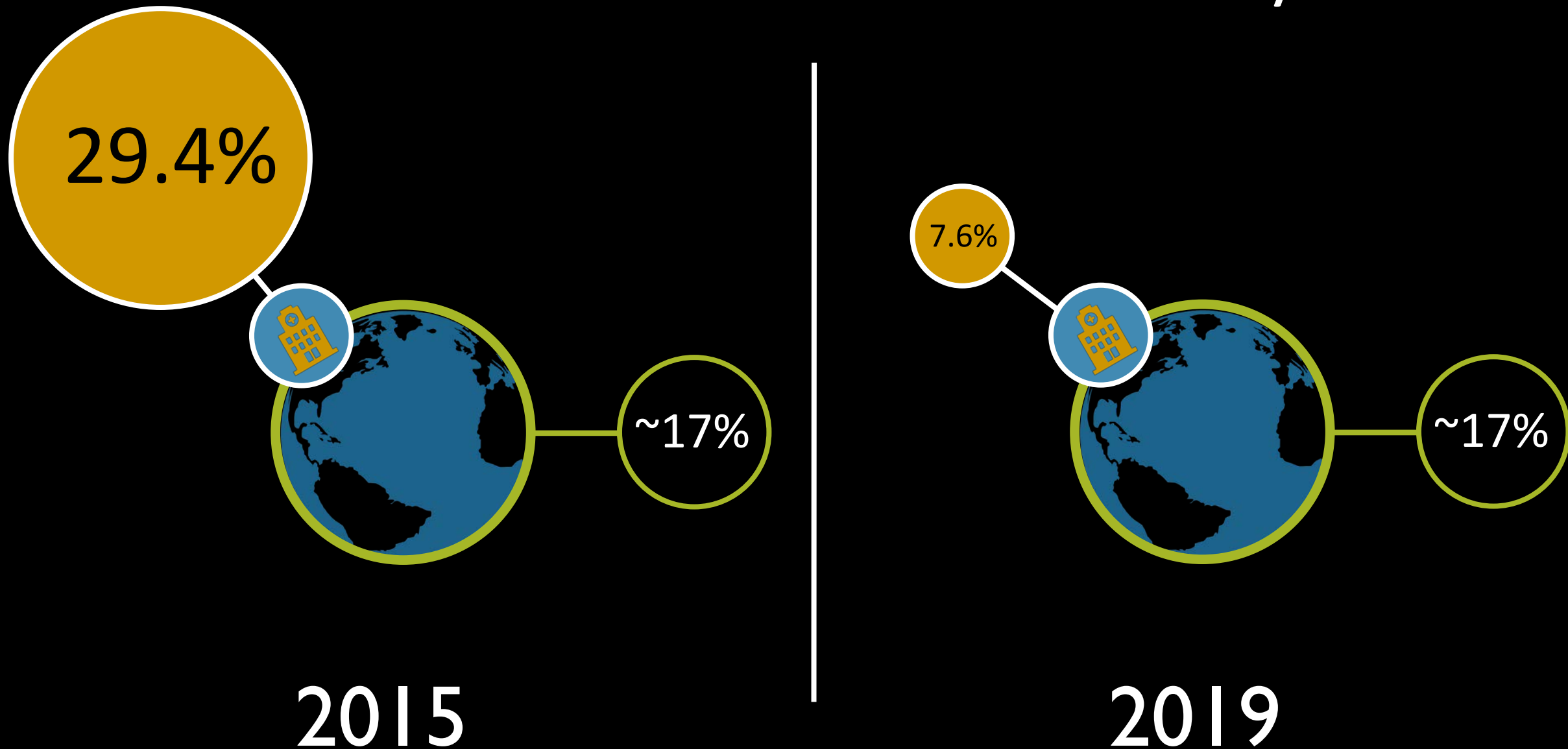
- Implemented June 14, 2018

Infective Endocarditis Mortality



2015

Infective Endocarditis Mortality





Overall Outcomes

Patient Outcome	2018-2019 (n=119)
Total Inpatient mortality, % (n)	7.6 (9)

Overall Outcomes

Patient Outcome	2018-2019 (n=119)
Definite IE, % (n)	64.7 (77)
Definite IE mortality, % (n)	5.2 (4)
Total Inpatient mortality, % (n)	7.6 (9)

Overall Outcomes

Patient Outcome	2018-2019 (n=119)
Definite IE, % (n)	64.7 (77)
Definite IE mortality, % (n)	5.2 (4)
Possible IE, % (n)	32.8 (39)
Possible IE mortality, % (n)	10.3 (4)
Total Inpatient mortality, % (n)	7.6 (9)

Definite Endocarditis with Surgical Indication Outcomes

Variable	2014 - 2015	2018-2019	P-Value
Definite IE and Surgical Indications (n)	68	56	
Inpatient Mortality (% , n)	29.4	7.1 (4)	<0.0001

Definite Endocarditis with Surgical Indication Outcomes

Variable	2014 - 2015	2018-2019	P-Value
Definite IE and Surgical Indications (n)	68	56	
Inpatient Mortality (% , n)	29.4	7.1 (4)	<0.0001
Surgery Performed (%)	41	55.4	0.12
Average time from admission to surgery (days)	14	11.4	0.29

Definite Endocarditis with Surgical Indication Outcomes

Variable	2014 - 2015	2018-2019	P-Value
Definite IE and Surgical Indications (n)	68	56	
Inpatient Mortality (% , n)	29.4	7.1 (4)	<0.0001
Surgery Performed (%)	41	55.4	0.12
Average time from admission to surgery (days)	14	11.4	0.29
Average length of hospital stay prior to Cardiac Surgery consult (days)	7.1	2	<0.0001

Definite Endocarditis with Surgical Indication Outcomes

Mortality	2014-2015	2018-2019	P-Value
Overall, % (n)	29.4 (20)	7.1 (4)	<0.0001
Medical Management, % (n)	45 (18)	16 (4)	0.02
Surgical Management, % (n)	7.1 (2)	0 (0)	0.13

Surgery for Active Endocarditis

Academic Year	Active Endocarditis Surgical Cases
Annual Average (2014-2018)	35.75
2018-2019	52

Microbiologic Diagnoses

Microorganism	2014-2015 (n = 68)	2018-2019 (n = 56)	P-Value
MSSA, % (n)	14.7 (10)	26.8 (15)	0.10
MRSA, % (n)	10.3 (7)	10.7 ((6)	0.94
Coagulase Negative Staphylococcus, % (n)	10.3 (7)	5.4 (3)	0.32
Viridans Streptococcus, % (n)	17.6 (12)	23.2 (13)	0.44
Group B Streptococcus, % (n)	4.4 (3)	5.4 (3)	0.80
Enterococcus, % (n)	10.3 (7)	10.7 (6)	0.94
Fungal, % (n)	10.3 (7)	1.8 (1)	0.06
Polymicrobial, % (n)	8.8 (6)	3.6 (2)	0.24
Culture Negative, % (n)	4.4 (3)	5.4 (3)	0.80
Other, % (n)	8.8 (6)	7.1 (4)	0.73

Patient Variables

Variable	2014-2015 (n = 68)	2018-2019 (n = 56)	P-value
Average Age (years)	57.5	50.7	0.02
Male Gender, % (n)	60.3 (41)	62.5 (35)	0.80
OSH Transfers, % (n)	65.7 (44)	60.7 (34)	0.57
Average Days to Transfer	8.5	8.7	0.90
IV Drug Use, % (n)	14.7 (10)	14.3 (8)	0.95
Diabetes	26.5 (18)	16.1 (9)	0.16
ESRD	16.2 (11)	14.3 (8)	0.77
Acute Renal Failure	16.2 (11)	0 (0)	0.002
Prosthetic Valve, % (n)	51.5 (35)	28.6 (16)	0.01
Presence of CIED, % (n)	13.2 (9)	12.5 (7)	0.91
Aortic Valve Involvement	52.9 (39)	57.1 (32)	0.64
Mitral Valve Involvement	42.6 (29)	44.6 (25)	0.82
Cerebral Emboli, % (n)	27.9 (19)	50 (28)	0.01

Patient Variables

Variable	2014-2015 (n = 68)	2018-2019 (n = 56)	P-value
ICU Admission, % (n)	48.5 (33)	64.3 (36)	0.08
Vasopressor Requirement, % (n)	34.3 (23)	39.3 (22)	0.57
Mechanical ventilation, % (n)	29.9 (20)	55.4 (31)	0.004
Heart Failure from IE, % (n)	48.5 (33)	50.0 (28)	0.87
IE Complicated by Heart Block/Abscess, % (n)	26.5 (18)	23.2 (13)	0.67
Persistent Bacteremia, % (n)	7.4 (5)	16.1 (9)	0.13
Recurrent Emboli, % (n)	42.6 (29)	26.8 (15)	0.07
Vegetation >10 mm, % (n)	29.4 (20)	32.1 (18)	0.75
Mean STS Risk Score, %	11.8	9.8	0.40

Combined Cohort Regression Analysis for Predictors of In-Hospital Mortality

Variable	Estimate	Standard Error	Z-Value	P-Value
Age	-0.0237	0.018	-1.62	0.11
Gender	-1.055	0.582	-1.81	0.07
Diabetes	-1.210	0.572	-2.12	0.03
Prosthetic Valve	-0.754	0.526	-1.43	0.15
Heart Failure	-0.956	0.521	-1.83	0.07
Vasopressor	0.37	0.735	0.50	0.51
Mechanical Ventilation	-0.587	0.721	0.82	0.42
ICU Admission	-1.345	0.803	-1.68	0.09
Year	1.70	0.547	3.28	0.001

Propensity Matched Analysis

Outcome	2014-2015	2018-2019	t-statistic
Overall In-hospital Mortality, %	34	5.7	-2.91
Medical Management In-Hospital Mortality, %	52.2	13	2.39
Surgical Management In-Hospital Mortality, %	0	0	N/A
Patients Managed Surgically, %	37.8	56.7	1.63
Time to Surgery (days)	11.57	11.64	0.02

Multidisciplinary Endocarditis Team


- Changes in plan of care based upon involvement of Multidisciplinary Endocarditis Team

Change in Plan of Care	Proportion of case (n=56)
Any change	83.9 (47)
Change in antibiotic plan	62.5 (35)
Change in surgical planning	21.4 (12)
Recommended TEE	16.1 (9)
Recommended additional neurologic imaging	7.1 (4)
Recommended additional infectious work-up	7.1 (4)
Recommended other additional diagnostic imaging	23.2 (13)

Additional Research

Original Article | Published: 14 December 2019

Physician perceptions of a multidisciplinary endocarditis team

[Sami El-Dalati](#) , [Irina Khurana](#), [Nathaniel Soper](#), [Daniel Cronin](#), [Michael Shea](#), [Richard L. Weinberg](#), [James Riddell IV](#), [Laraine Washer](#), [Emily Shuman](#), [James Burke](#), [Sadhana Murali](#), [D. Alexander Perry](#), [Christopher Fagan](#), [Twisha Patel](#), [Kirra Ressler](#) & [George Michael Deeb](#)

European Journal of Clinical Microbiology & Infectious Diseases **39**, 735–739(2020) | [Cite this article](#)

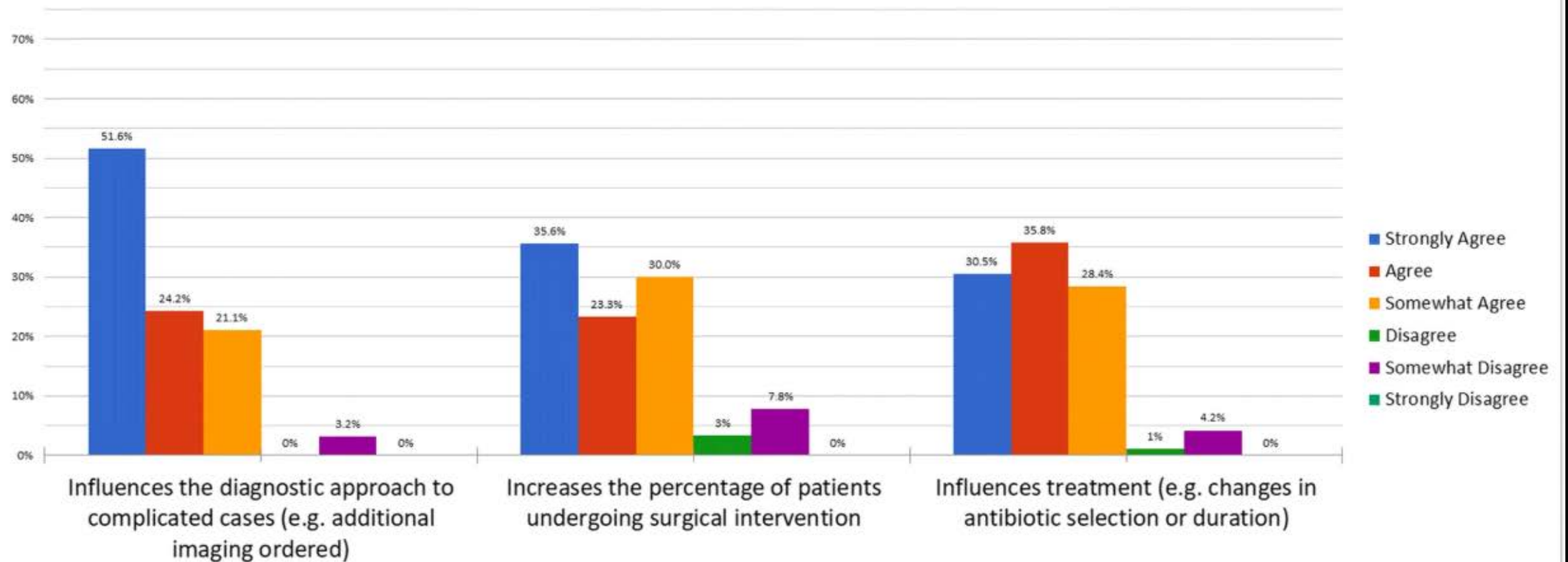
Additional Research

Specialty	Number of responses	% of total responses	Response rate (%)
Cardiac surgery	6	5%	6/24 (25%)
Cardiology	28	22%	28/104 (27%)
General internal medicine	73	58%	73/263 (28%)
Infectious diseases	19	15%	19/30 (63%)
Total	126	100%	126/421 (30%)
Level of training	Number	% of respondents	
Faculty	71	56%	
Fellow	4	3%	
Intern	19	15%	
Resident	32	26%	

Additional Research

a

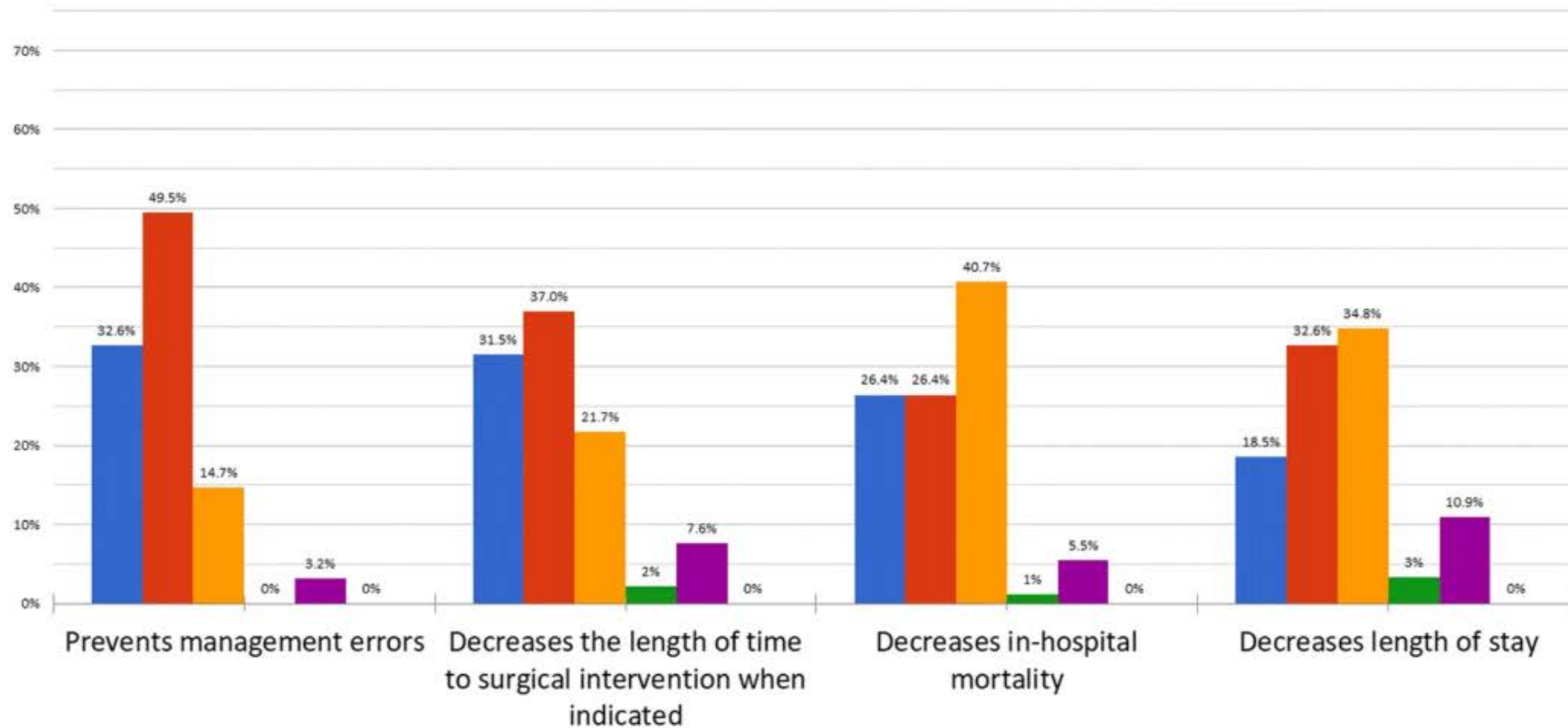
Perceptions of Effects on Diagnosis and Treatment



Additional Research

b

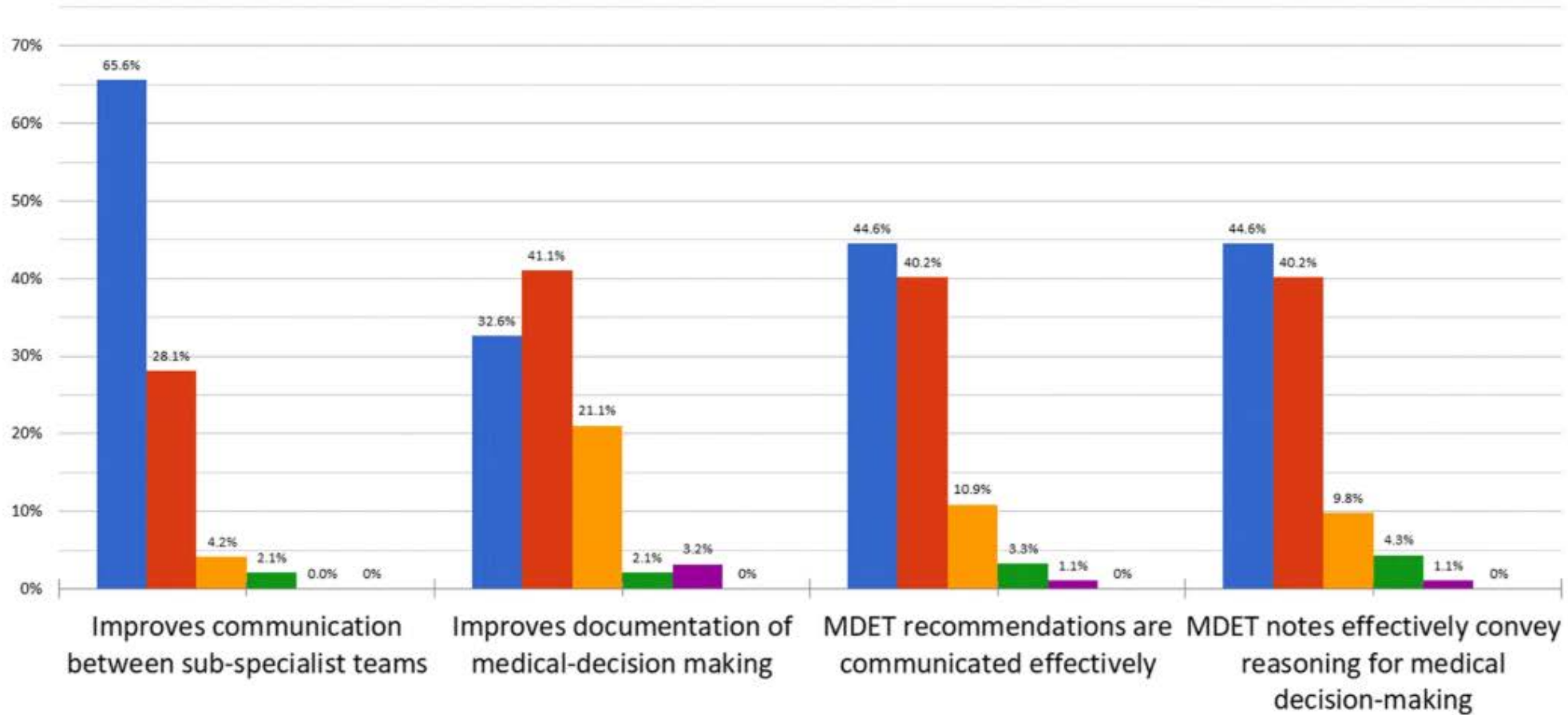
Effects on Mortality, Length of Stay, and Errors



Additional Research

C

Communication and Documentation



Additional Team Research

Heart Valve Infection Prevention Patient Card



- You are at increased risk for heart valve infection
- You should take antibiotics before certain procedures (see reverse)
- Show this card to your medical provider
- Please seek medical attention for:
 - Fevers (temperature > 100.4 F or 38.0 C)
 - Unexplained chills or shakes
 - Night sweats
- Please ask your doctor to collect blood cultures for the above symptoms and before starting antibiotics

Additional Team Research

Heart Valve Infection Prevention Provider Card

- Antibiotic Prophylaxis against bacterial endocarditis is recommended for the following procedures
 - Dental cleanings, cavity fillings, tooth extractions, draining dental abscesses
 - Tonsillectomy and/or adenoidectomy
 - Bronchoscopy with biopsy
- Please consider obtaining 2 sets of blood cultures in this patient for
 - Unexplained febrile illness
AND/OR
 - Before starting oral or IV antibiotics
- For questions please call the Michigan Medicine Infectious Diseases Clinic at 734-647-5899 or the Cardiac Surgery Clinic at 888-287-1082

UPMC Endocarditis Work Group

- Multidisciplinary team comprised of:
 - Cardiac Surgery
 - Addiction Medicine
 - Infectious Diseases
 - Neurology
 - Psychiatry
 - Pharmacy
 - Social work
- Meet weekly on Tuesday from 2-3 PM via Teams

Future Directions

Development of a stand-alone Infectious Diseases Consult Service focusing on patients with endocarditis

Initially staffed by 1 attending physician and 1 APP

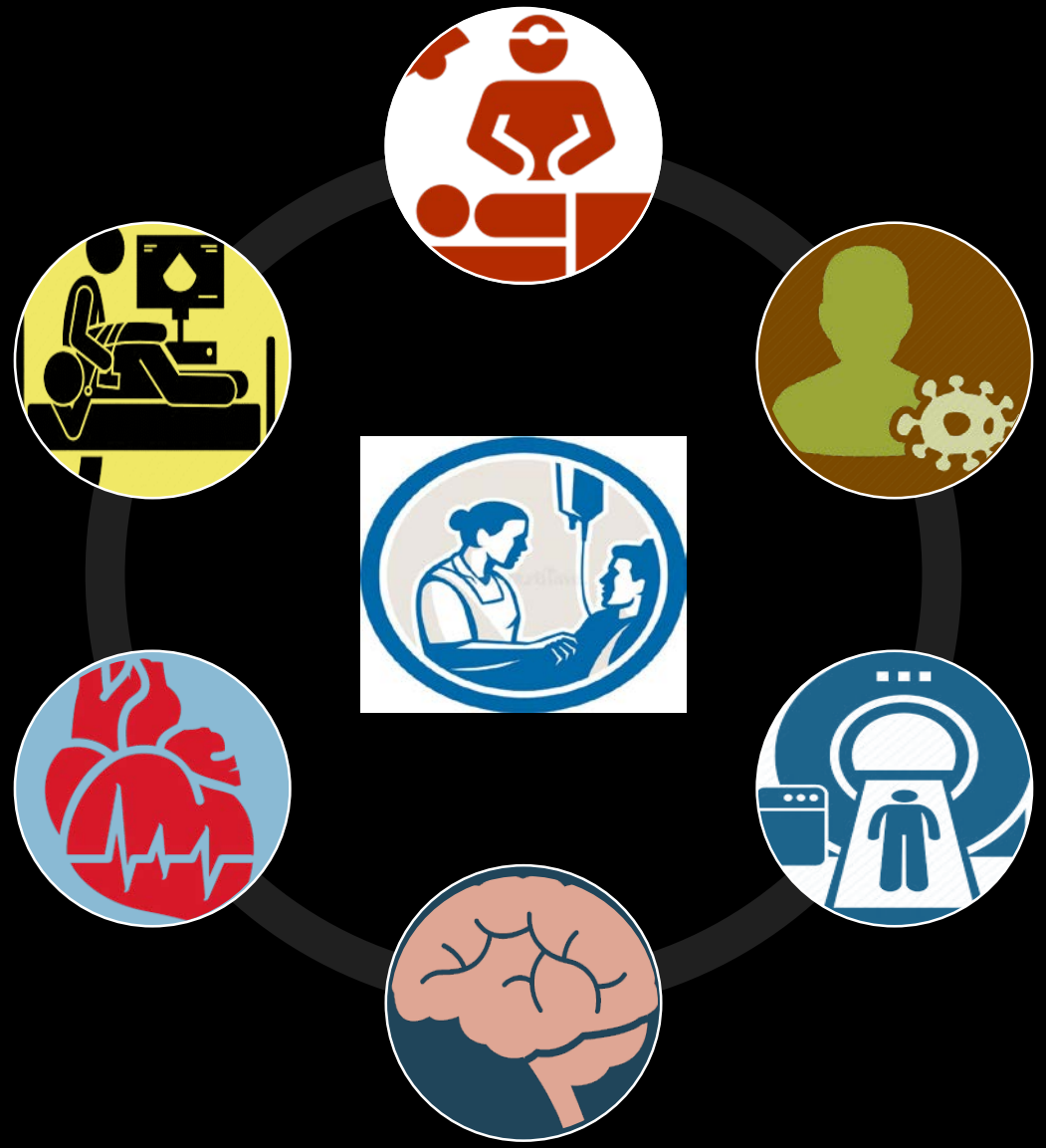
- Will provide continuity for inpatients throughout their hospitalization
- Will help to standardize practice
- Serve as a liaison between ID, addiction medicine, and cardiac surgery

Future Directions

- Development of a protocol to select patients for:
 - Courses of oral antibiotics
 - Shorter durations of therapy in patients who undergo surgery
- Standardize Endocarditis Team Documentation

Acknowledgments

- Dan Cronin MD
- Elizabeth O'Donnell PhD
- Rishi Chanderraj MD
- Chris Fagan MD
- Paul Christine MD, PhD
- Cardiology: Michael Shea MD, Richard Weinberg MD, PhD
- Cardiac Surgery: Michael Deeb MD, Kirra Ressler PA-C, Shinichi Fukuhara MD, Matthew Romano MD, Bo Yang MD
- ID: Jamie Riddell MD, Dan Kaul MD, Laraine Washer MD, Emily Stoneman MD, Suzanne Bradley MD, Alex Perry MD
- Pharmacy: Twisha Patel PharmD
- Neurology: James Burke MD, Sadhana Murali MD
- Social Work: Karissa Canfield MSW



References

- Bor DH, Woolhandler S, Nardin R, Bruschi J, Himmelstein DU. Infective Endocarditis in the U.S., 1998–2009: A Nationwide Study. Wertheim HFL, ed. *PLoS ONE*. 2013;8(3):e60033. doi:10.1371/journal.pone.0060033.
- Kang D, Kim Y, Kim S, et al. Early Surgery versus Conventional Treatment for Infective Endocarditis. *The New England Journal of Medicine* 2012; 366 (26). 2466-73.
- Li J, Sexton D, Mick N, et al. Proposed Modifications to the Duke Criteria for the Diagnosis of Infective Endocarditis. *Clinical Infectious Diseases* 2000; 30 (4). 633–638.
- Baddour L, Wilson W, Bayer A, et al. Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications A Scientific Statement for Healthcare Professionals From the American Heart Association. *Circulation* 2015; 132. 1-53.
- Botelho-Nevers E, Thuny F, Casalta JP et al. Dramatic Reduction in Infective Endocarditis–Related Mortality With a Management-Based Approach. *Arch Intern Med*. 2009;169(14):1290-1298.

References

- Kang D, Kim Y, Kim S, et al. Early Surgery versus Conventional Treatment for Infective Endocarditis. *The New England Journal of Medicine* 2012; 366 (26). 2466-73.
- Li J, Sexton D, Mick N, et al. Proposed Modifications to the Duke Criteria for the Diagnosis of Infective Endocarditis. *Clinical Infectious Diseases* 2000; 30 (4). 633–638.
- Baddour L, Wilson W, Bayer A, et al. Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications A Scientific Statement for Healthcare Professionals From the American Heart Association. *Circulation* 2015; 132. 1-53.
- Botelho-Nevers E, Thuny F, Casalta JP et al. Dramatic Reduction in Infective Endocarditis–Related Mortality With a Management-Based Approach. *Arch Intern Med*. 2009;169(14):1290-1298.
- Carrasco-Chinchilla F, Sanchez-Espin G, Ruiz-Morales J et al. Influence of a Multidisciplinary Alert Strategy on Mortality Due to Left-sided Infective Endocarditis. *Spanish Society of Cardiology*. 2014;67(5):380–386.

References

- Shrestha et al. Sensitivity and Specificity of Duke Criteria for Diagnosis of Definite Endocarditis: A Cohort Study. *Open Forum Infectious Diseases*. 2017; 4 (1), S550-S551. *Open Forum Infectious Diseases*.
- Wilson et al. Prevention of Infective Endocarditis Guidelines From the American Heart Association A Guideline From the American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki Disease Committee, Council on Cardiovascular Disease in the Young, and the Council on Clinical Cardiology, Council on Cardiovascular Surgery and Anesthesia, and the Quality of Care and Outcomes Research Interdisciplinary Working Group. *Circulation* 2007; 117:1736-1754.
- 2017; 4 (1), S550-S551.
- Fowler et al. Staphylococcus aureus endocarditis: a consequence of medical progress. *JAMA*. 2005; 293 (24): 3012.
- Habib et al. 2015 ESC Guidelines for the management of infective endocarditis: The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC) Endorsed by: European Association for Cardio-Thoracic Surgery (EACTS), the European Association of Nuclear Medicine (EANM). *European Heart Journal*. 2015; 36 (44), 3075-3128.
- Delahaye et al. Systematic Search for Present and Potential Portals of Entry for Infective Endocarditis. *Journal of the American College of Cardiology*. 2016; 67 (2), 151-158.



Questions?

eldalatisa@upmc.edu