

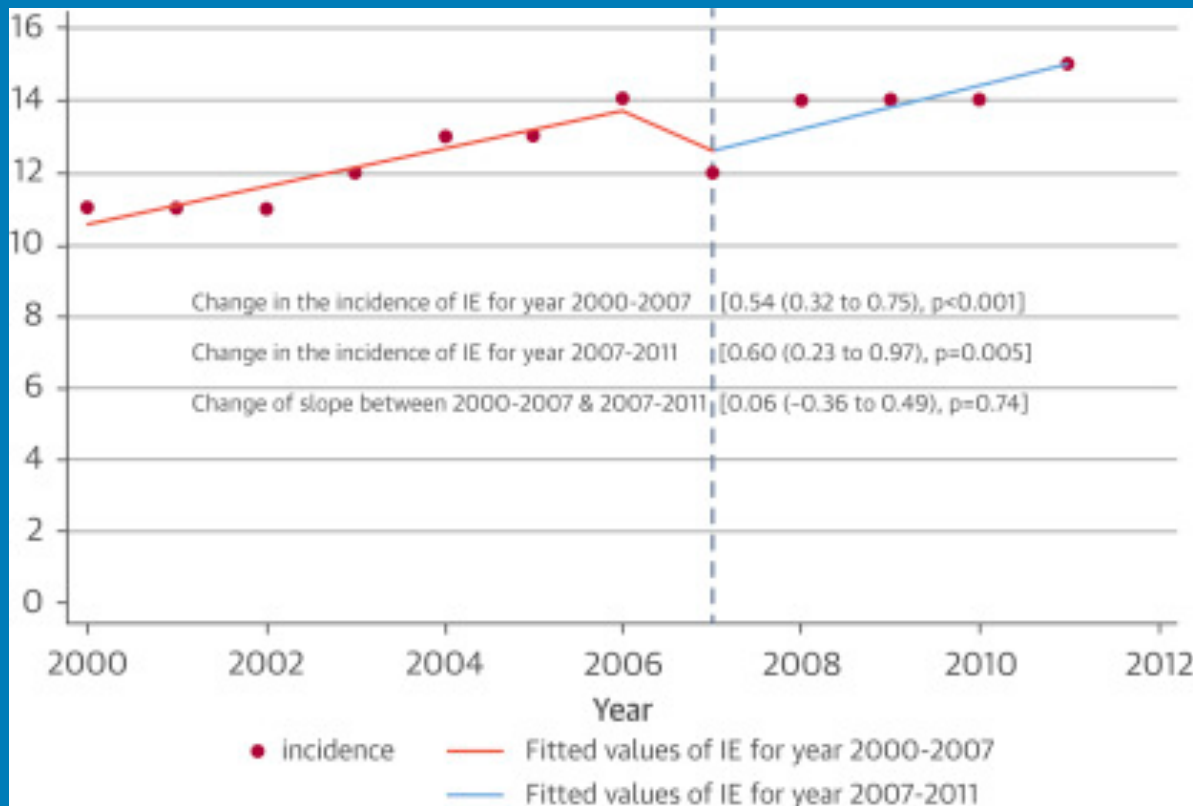


Endocarditis: When Is Early Surgery Indicated?

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No disclosures

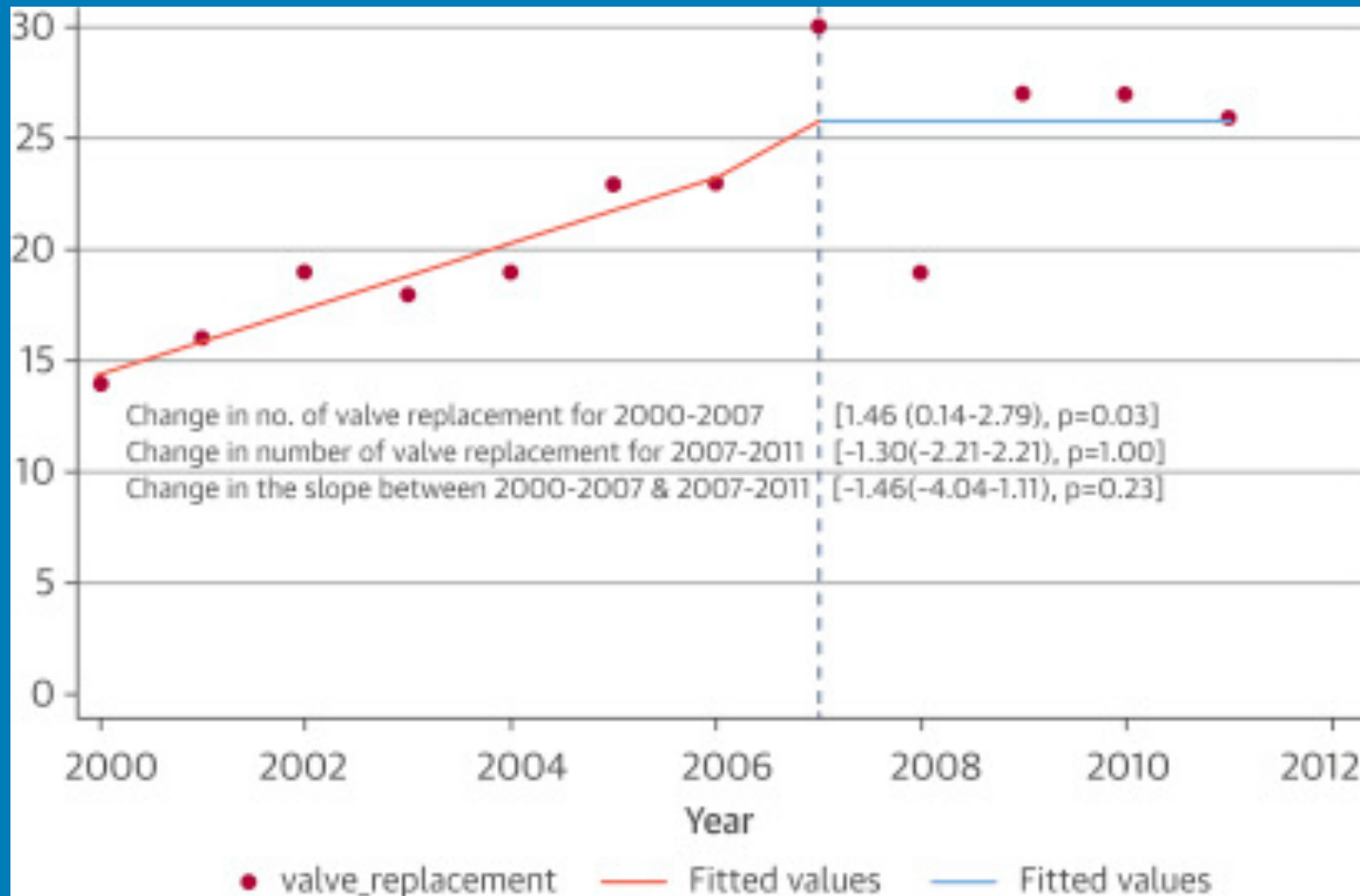
Trend in the Incidence of IE Hospitalization in the United States (per 100,000 Population)



Surgical Management of Infective Endocarditis

- **Proportion of cases undergoing surgery increased 7% per decade from 1969-2000**
- **Surgical cases equally divided between prosthetic and native valve endocarditis**
- **Only 1 small prospective clinical trial of early surgery vs medical therapy**
- **Observational studies provide basis of recommendations**
- **Multiple new guidelines AHA 2015, ESC 2015, AATS 2016**

Valve Replacement Rates for IE (per 1,000 IE Cases) in the United States From 2000 to 2011



Endocarditis Team – ESC Guidelines

Recommendations	Class ^a	Level ^b	Ref. ^c
Patients with complicated IE should be evaluated and managed at an early stage in a reference centre, with immediate surgical facilities and the presence of a multidisciplinary 'Endocarditis Team', including an ID specialist, a microbiologist, a cardiologist, imaging specialists, a cardiac surgeon and, if needed, a specialist in CHD	IIa	B	12,56
For patients with uncomplicated IE managed in a non-reference centre, early and regular communication with the reference centre and, when needed, visits to the reference centre should be made	IIa	B	12,56

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

AATS Surgical Treatment of Infective Endocarditis Consensus Guidelines Writing Committee Chairs., Pettersson GB, Coselli JS; Writing Committee., Pettersson GB, Coselli JS, Hussain ST, Griffin B, Blackstone EH, Gordon SM, LeMaire SA, Woc-Colburn LE.J Thorac Cardiovasc Surg. 2017 (e-pub)

Recommendations	COR	LOE	References
1. Who should care for and operate on patients with IE?			
Patients with suspected IE should ideally be cared for at centers with access to a complete team, including cardiology, infectious disease, cardiac surgery, and other services needed to handle IE complications	I	B	4,5,7,89
Surgeons operating on patients with IE should be well-trained, experienced valve surgeons who are well versed in the different reconstruction techniques needed by patients with advanced disease	I	C	4,5,31,89
2. Diagnosis of IE: What does the surgeon need to know?			
At the time of surgery the patient should be on an effective antimicrobial regimen (correct dosage and route of administration) to which the causative microorganism is sensitive, or be broadly covered when organism and sensitivity are unknown	I	B	3-5,7,55,58
For surgery planning, the surgeon should have the best possible understanding of the pathology. This will usually require advanced imaging techniques, such as TEE	I	B	3-5,7,90-98
Use of imaging modalities other than echocardiography may also be appropriate in selected cases	IIb	C	3-5,95,99-103

Early Valve Surgery in Left-Sided NVE: Recommendations – AHA Guidelines 2015

1. Early surgery (during initial hospitalization and before completion of a full course of antibiotics) is indicated in patients with IE who present with valve dysfunction resulting in symptoms or signs of heart failure (Class I; Level of Evidence B).
2. Early surgery should be considered particularly in patients with IE caused by fungi or highly resistant organisms (eg, vancomycin-resistant Enterococcus, multidrug-resistant Gram-negative bacilli) (Class I; Level of Evidence B).
3. Early surgery is indicated in patients with IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions (Class I; Level of Evidence B).
4. Early surgery is indicated for 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 I; Level of Evidence B).

Early Valve Surgery in Left-Sided NVE: Recommendations – AHA Guidelines 2015

5. Early surgery is reasonable in patients who present with recurrent emboli and persistent or enlarging vegetations despite appropriate antibiotic therapy (Class IIa; Level of Evidence B).
6. Early surgery is reasonable in patients with severe valve regurgitation and mobile vegetations >10 mm (Class IIa, Level of Evidence B).
7. Early surgery may be considered in patients with mobile vegetations >10 mm, particularly when involving the anterior leaflet of the mitral valve and associated with other relative indications for surgery (Class IIb; Level of Evidence C).

Early Valve Surgery in PVE: Recommendations – AHA Guidelines

1. Early surgery is indicated in patients with symptoms or signs of heart failure resulting from valve dehiscence, intracardiac fistula, or severe prosthetic valve dysfunction (Class I; Level of Evidence B).
2. Early surgery should be done in patients who have persistent bacteremia despite appropriate antibiotic therapy for 5 to 7 days in whom other sites of infection have been excluded (Class I; Level of Evidence B).
3. Early surgery is indicated when IE is complicated by heart block, annular or aortic abscess, or destructive penetrating lesions (Class I; Level of Evidence B).
4. Early surgery is indicated in patients with PVE caused by fungi or highly resistant organisms (Class I; Level of Evidence B).

Early Valve Surgery in PVE: Recommendations – AHA Guidelines

5. Early surgery is reasonable for patients with PVE who have recurrent emboli despite appropriate antibiotic treatment (Class IIa; Level of Evidence B).
6. Early surgery is reasonable for patients with relapsing PVE (Class IIa; Level of Evidence C).
7. Early surgery may be considered in patients with mobile vegetations >10 mm (Class IIb; Level of Evidence C).

Valve Surgery in Patients With Right-Sided IE

- **Treat medically, avoid prostheses if feasible especially IVDA due to risk of recurrence**
- **Surgery if:**
 - **Right heart failure with severe TR**
 - **Lack of response to antibiotics**
 - **Tricuspid valve vegetations > 20 mm and recurrent pulmonary embolism despite antibiotics**

Valve Surgery in Patients With Right-Sided IE – AHA Guidelines

1. Surgical intervention is reasonable for patients with certain complications (Class IIa; Level of Evidence C).
2. Valve repair rather than replacement should be performed when feasible (Class I; Level of Evidence C).
3. If valve replacement is performed, then an individualized choice of prosthesis by the surgeon is reasonable (Class IIa; Level of Evidence C).
4. It is reasonable to avoid surgery when possible in patients who are IDUs (Class IIa; Level of Evidence C).

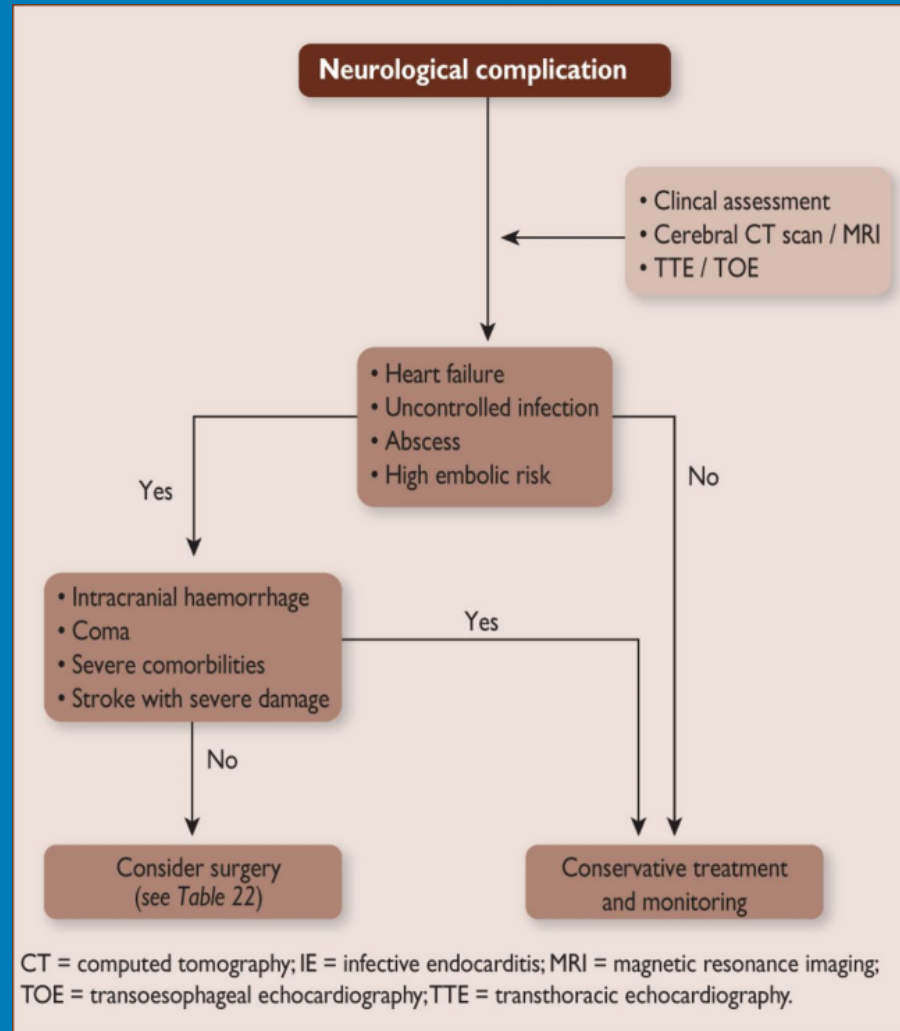
Valve Surgery in Patients with Prior Emboli/ Hemorrhage/Stroke

- Stroke is a risk factor for mortality after surgery in IE
- Risk of further bleeding due to anticoagulation during surgery or increased ischemia due to hypotension with CPB
- Japanese study showed mortality 67% when surgery performed within 24 hours of stroke declining to 7% at 4 weeks
- In ischemic stroke, time to surgery is less relevant in several studies
- In cohort of 198 patients with IE and stroke, 58 went to OR within 1 week vs 140 after 8 days, early surgery was not risk factor when allowing for other comorbidities
- In hemorrhagic stroke surgery within 4 weeks had 75% mortality vs 40% after 4 weeks

Valve Surgery in Patients with Prior Emboli/ Hemorrhage/Stroke – AHA Guidelines

- 1. 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).**
- 2. 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).**

Therapeutic strategies for patients with infective endocarditis and neurological complications



Embolization in Infectious Endocarditis

- Occurs in 22-50% cases and may be higher if actively sought with imaging
- Mitral valve endocarditis (25% mitral vs 10% aortic) especially anterior leaflet (37%)
- Infection with *S aureus*, candida and HACEK
- Declines within 1st 2 weeks of antibiotic therapy
- Stroke risk 3.1% after 1st week of therapy
- Increasing vegetation size on therapy a poor prognostic sign
- Size of vegetation and embolic risk is still controversial though larger newer studies suggest correlation
- 10 mm vs 15 mm size cutoff

Embolization in Infectious Endocarditis – AHA Guidelines 2015

Recommendations

1. Discontinuation of all forms of anticoagulation in patients with mechanical valve IE who have experienced a CNS embolic event for at least 2 weeks is reasonable (Class IIa; Level of Evidence C).
2. Initiation of aspirin or other antiplatelet agents as adjunctive therapy in IE is not recommended (Class III; Level of Evidence B).
3. The continuation of long-term antiplatelet therapy at the time of development of IE with no bleeding complications may be considered (Class IIb; Level of Evidence B).

Periannular Extension of Infection

- TTE insensitive in detection
- TEE high sensitivity and specificity but may also fail to detect periannular extension especially at mitral valve
- TEE is diagnostic modality of 1st choice
- Usually require surgery, earlier the better

Periannular Extension of Infection

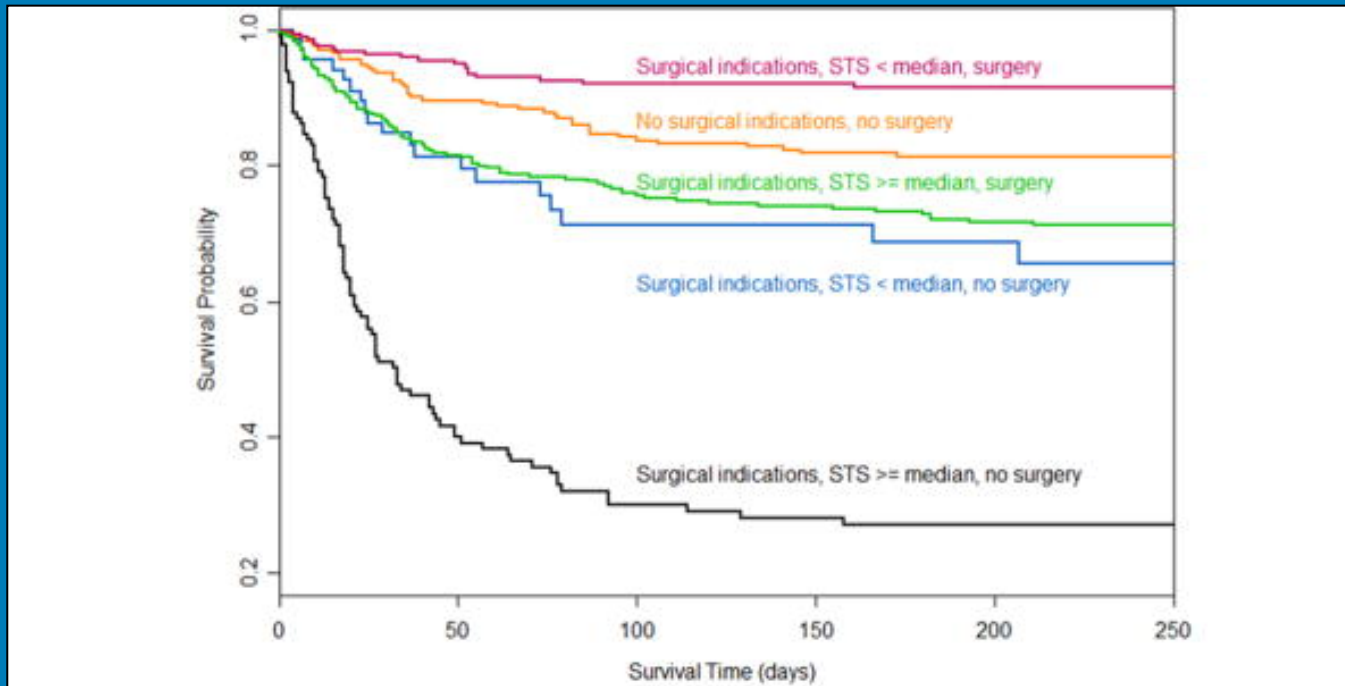
- Higher mortality rate, more CHF, need for cardiac surgery
- Commoner in aortic than mitral or tricuspid IE
- Occurs in 10-40% native valve endocarditis
- In prosthetic endocarditis, may occur in 56-100%
- May develop fistulous tracks – high mortality even when treated surgically
- Persistent fever, bacteremia, heart block, new murmur
- New AV block has positive predictive value of 88% for abscess but only 45% sensitivity

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2. When should the patient undergo operation?			
Once an indication for surgery is established, the patient should be operated on within days	I	B	3-6
Earlier surgery (emergency or within 48 hours) is reasonable for patients with large mobile vegetations at imminent risk of embolism	IIa	B	3-6,46,62,133,137,138
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)	IIa	B	3-6,33,61-63,67,69,104,108,110,125,137,139-154

Survival according to presence of surgical indication, Society of Thoracic Surgeons (STS)-infective endocarditis (IE) score, and surgical treatment



Surgery Subgroup	Day 0 - 49		Day 50 - 99		Day 100 - 149		Day 150 - 199		Day 200 - 250		Day >250	
	# at risk	# died	# at risk	# died	# at risk	# died	# at risk	# died	# at risk	# died	# at risk	# died
Indication/ STS<22/ Surgery	246	13	166	6	164	0	148	1	123	0	66	0
No indication/ No surgery	288	28	200	12	178	5	157	1	134	0	62	0
Indication/ STS≥22/ Surgery	348	65	244	17	208	5	183	6	152	1	70	1
Indication/ STS<22/ No surgery	62	12	42	5	32	0	28	1	22	1	10	0
Indication/ STS≥22/ No surgery	126	75	44	11	30	2	24	1	18	0	10	2

Main Campus



ESC Guidelines – Indications for Surgery

Indications for surgery	Timing ^a	Class ^b	Level ^c	Ref. ^d
1. Heart failure				
Aortic or mitral NVE or PVE with severe acute regurgitation, obstruction or fistula causing refractory pulmonary oedema or cardiogenic shock	Emergency	I	B	111,115, 213,216
Aortic or mitral NVE or PVE with severe regurgitation or obstruction causing symptoms of HF or echocardiographic signs of poor haemodynamic tolerance	Urgent	I	B	37,115, 209,216, 220,221
2. Uncontrolled infection				
Locally uncontrolled infection (abscess, false aneurysm, fistula, enlarging vegetation)	Urgent	I	B	37,209, 216
Infection caused by fungi or multiresistant organisms	Urgent/ elective	I	C	
Persisting positive blood cultures despite appropriate antibiotic therapy and adequate control of septic metastatic foci	Urgent	IIa	B	123
PVE caused by staphylococci or non-HACEK gram-negative bacteria	Urgent/ elective	IIa	C	
3. Prevention of embolism				
Aortic or mitral NVE or PVE with persistent vegetations >10 mm after one or more embolic episode despite appropriate antibiotic therapy	Urgent	I	B	9,58,72, 113,222
Aortic or mitral NVE with vegetations >10 mm, associated with severe valve stenosis or regurgitation, and low operative risk	Urgent	IIa	B	9
Aortic or mitral NVE or PVE with isolated very large vegetations (>30 mm)	Urgent	IIa	B	113
Aortic or mitral NVE or PVE with isolated large vegetations (>15 mm) and no other indication for surgery ^e	Urgent	IIb	C	

ESC Guidelines – IE, Stroke and Surgery

Recommendations	Class ^a	Level ^b	Ref. ^c
After a silent embolism or transient ischaemic attack, cardiac surgery, if indicated, is recommended without delay	I	B	105, 263
Neurosurgery or endovascular therapy is recommended for very large, enlarging or ruptured intracranial infectious aneurysms	I	C	
Following intracranial haemorrhage, surgery should generally be postponed for ≥ 1 month	IIa	B	264–266
After a stroke, surgery indicated for HF, uncontrolled infection, abscess, or persistent high embolic risk should be considered without any delay as long as coma is absent and the presence of cerebral haemorrhage has been excluded by cranial CT or MRI	IIa	B	9,263
Intracranial infectious aneurysms should be looked for in patients with IE and neurological symptoms. CT or MR angiography should be considered for diagnosis. If non-invasive techniques are negative and the suspicion of intracranial aneurysm remains, conventional angiography should be considered	IIa	B	267, 268

Recommendations	COR	LOE	References
1. What are the indications for surgery in patients with IE?			
Surgery during initial hospitalization independently of the completion of a full therapeutic course of antibiotics is indicated in patients with IE who present with valve dysfunction resulting in symptoms of heart failure	I	B	3-7,9,11,46,104-114
Surgery during initial hospitalization independently of the completion of a full therapeutic course of antibiotics is indicated in patients with left-sided IE caused by <i>S. aureus</i> , fungal, or other highly resistant microorganisms	I	B	3-5,7,9,18,31,40,105,110,115-121
Surgery during initial hospitalization independently of completion of a full therapeutic course of antibiotics is indicated in patients with IE complicated by heart block, annular or aortic abscess, or destructive penetrating lesions	I	B	3-7,11,43,85,105,106,108-110,122-129
Surgery during initial hospitalization independently of the completion of a full therapeutic course of antibiotics for IE is indicated in patients with evidence of persistent infection as manifested by persistent bacteremia or fever lasting longer than 5 to 7 days after initiation of appropriate antimicrobial therapy	I	B	3-5,7,45,105,106,110,118,120,130
Surgery is recommended for patients with PVE and relapsing infection (defined as recurrence of bacteremia after a complete course of appropriate antibiotics and subsequently negative blood cultures) without other identifiable source for portal of infection	IIa	C	106
Surgery during initial hospitalization independently of the completion of a full therapeutic course of antibiotics is reasonable in patients with IE who present with recurrent emboli and persistent vegetations despite appropriate antibiotic therapy	IIa	B	3-6,47,61,63,91,131-134
Urgent or even emergency surgery may be considered in patients with NVE or PVE who exhibit mobile vegetations greater than 10 mm in length with clinical evidence of embolic phenomena despite appropriate antimicrobial treatment	IIb	B	31,47,63,91,135
In patients with right-sided IE in addition to symptomatic severe valve dysfunction, surgery should be considered for NVE or PVE when large vegetations are present and there is evidence of persistent infection manifested by persistent bacteremia or fevers lasting longer than 5 to 7 days after initiation of appropriate antimicrobial therapy, or in those with evidence of septic pulmonary embolism	IIb	B	4,7,136

2. When should the patient undergo operation?

Once an indication for surgery is established, the patient should be operated on within days	I	B	3-6
Earlier surgery (emergency or within 48 hours) is reasonable for patients with large mobile vegetations at imminent risk of embolism	IIa	B	3-6,46,62,133,137,138
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)	IIa	B	3-6,33,61-63,67,69,104,108,110,125,137,139-154

Recommendations	COR	LOE	References
1. What is the effect of neurologic complications, embolic stroke, brain hemorrhage, and mycotic aneurysm on indication for and timing of surgery?			
If a cerebral mycotic aneurysm has been diagnosed, treatment and follow-up of the patient should be in close collaboration with neurologic and neurosurgery expertise	I	C	3,4,6,155
In patients with a recent intracranial hemorrhage, a delay of operation for 3 or more weeks is reasonable	Ila	B	3-6,138,141,156-159
Earlier surgery is reasonable for patients with non-hemorrhagic strokes and a strong cardiac indication for urgent surgery	Ila	B	3-6,69,157,160-162
Patients with large and multiple strokes and severe neurologic symptoms should be carefully evaluated by a neurologist before being offered surgery	I	B	3,4,6
For patients with IE and neurologic symptoms and significant intracranial hemorrhage, angiography should be considered to rule out mycotic aneurysm	Ila	B	3,4,6,155
2. Should all patients with IE scheduled for surgery have preoperative brain imaging?			
Endocarditis patients with neurologic symptoms should have brain imaging	I	B	3,4,6
It is reasonable to screen patients with left-sided IE for possible stroke or intracranial bleeding before operation, particularly if they have cardiac lesions considered high risk for embolic events	Ila	B	66-68,70
3. What workup is needed for diagnosing primary infectious focus, secondary manifestations and complications (other than neurologic), and satellite infections in patients with IE?			
Patients with IE should be screened for primary noncardiac focus of infection, noncardiac complications, and satellite infections: The choice of diagnostic procedure (e.g., CT, MRI, ultrasonography) varies, and the selection should be individualized for each patient based on clinical symptoms and suspicions	I	C	3,4
4. How should anticoagulation in patients with IE, with and without stroke or intracranial bleeding, be managed?			
Anticoagulation management in patients who have compelling indications for anticoagulation, e.g., atrial fibrillation, mechanical prosthetic valve, deep vein thrombosis, or pulmonary embolism, has to seek compromises, taking all risks and benefits into consideration	I	C	163-176
Heparin should be used cautiously in all patients with IE, particularly when there is evidence of brain hemorrhage, and be temporarily withheld in patients with higher risk of rebleed	I	B	4,164

Recommendations	COR	LOE	References
1. What additional workup is needed just before taking the patient to surgery?			
When surgery is decided upon, before going to the operating room, it is reasonable to obtain brain imaging or repeat brain imaging	IIa	B	67,68,70
The need for preoperative coronary angiography should be guided by normal criteria. This is particularly important if the patient has had coronary artery bypass grafting. In patients with large aortic valve vegetations, CT angiography is an alternative to assess the coronary arteries	I	C	3,4,6,177
When repeat sternotomy is required, computed tomography of the chest is recommended when possible to assess risk of sternal reentry	IIa	C	178
2. Is preoperative duration of antibiotic treatment important?			
The patient should be on an effective antimicrobial regimen at the time of surgery. Ideally, the sensitivity of the causative organism is known	I	B	3-5,7,55,58
Once the patient is on an effective antimicrobial regimen, further delay of surgery is unlikely to be beneficial	IIa	B	3-5,7,77,104,110,125,179-181
3. What is the risk of operation for IE?			
The patient should be quoted a risk, taking into consideration all factors known to affect the risk of the operation	I	C	34,78,79,182

Recommendations	COR	LOE	References
1. Intraoperative TEE			
Intraoperative TEE is mandatory when performing surgery for IE	I	B	3-5,80,90,97,183-187
2. Operative approach			
Medium sternotomy is the recommended approach, with few exceptions	I	C	
3. Removal of infected tissue: Radical debridement			
All infected and necrotic tissue and foreign material should be radically debrided and removed	I	B	43,85
4. Choice of reconstruction and valve replacement: General considerations and recommendations			
For patients with NVE and infection limited to the valve cusps or leaflets, repair is performed whenever possible	I	B	3-6,43,152,188-198
When simple valve replacement is required, choice of valve—mechanical or tissue prosthesis—should be based on normal criteria: age, life expectancy, comorbidities, and expected compliance with anticoagulation	I	B	4-6,197,199-201
It is reasonable to avoid use of mechanical prostheses in patients with any intracranial bleeding or those who have suffered a major stroke	Ila	C	
For patients with invasive disease and destruction, reconstruction should depend on the involved valve, severity of destruction, and available options for cardiac reconstruction	I	B	6,43,44,85,111,202,203
5. Native aortic valve IE			
For patients with native aortic valve IE and infection limited to the valve cusps, repair may occasionally be possible. Choice of replacement valve—mechanical or tissue prosthesis—should be based on usual criteria	I	B	4-6,43,83,197-201
For invasive and destructive native aortic valve IE requiring root reconstruction and replacement, using an allograft may be beneficial, but a prosthetic bioroot or prosthetic valved conduit with a mechanical or bioprosthetic valve are acceptable alternatives, with choice guided by surgeon training and experience	Ila	B	6,8,44,81,82,199,200,204-208
6. Prosthetic aortic valve IE			
If the root and the annulus are preserved after radical debridement, it is reasonable to implant a new prosthetic valve—mechanical or tissue—based on normal criteria	Ila	B	6,44
If there is annulus destruction and invasion outside the aortic root and root reconstruction and replacement is required, an allograft or a biologic tissue root is preferable to a prosthetic valved conduit	Ila	B	6,8,44,81-83,85,200,202,204,206-217

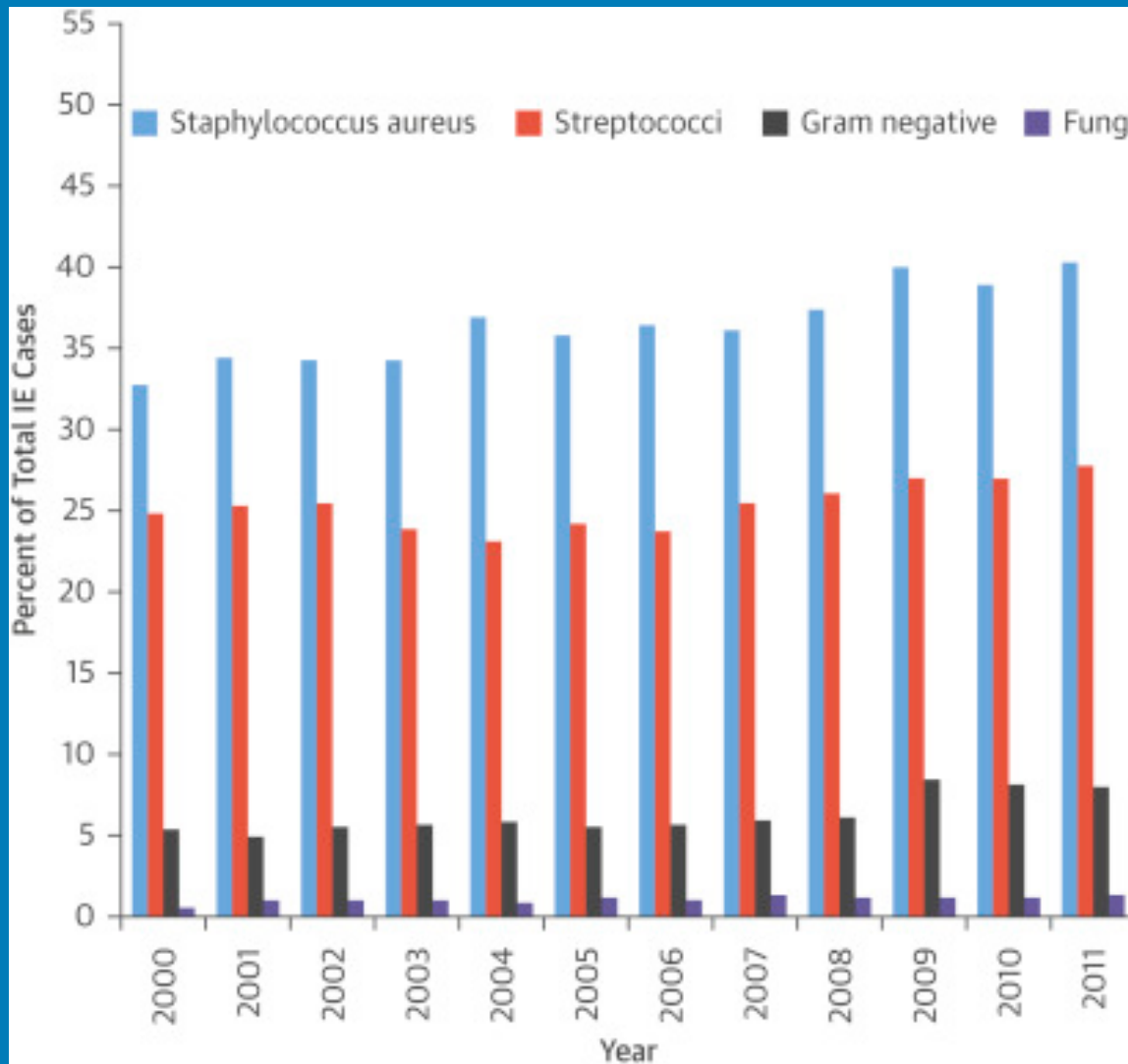
7. Native mitral valve IE			
Mitral valve repair is the preferred choice whenever possible, including use of a prosthetic annuloplasty ring when appropriate	I	B	43,152,188-196
When valve replacement is required, a prosthetic valve, either mechanical or tissue, is acceptable, unless there is risk of intracranial bleeding, in which case a tissue valve is preferred	Ila	B	4-6,199,201
When there is annulus destruction and invasion, the mitral annulus is reconstructed and the valve prosthesis anchored to the ventricular muscle or to the reconstruction patch in a way that prevents leakage and pseudoaneurysm development beneath the prosthesis	Ila	B	43,188,192,203
8. Prosthetic mitral valve IE			
A new prosthetic mitral valve, mechanical or tissue, is acceptable, unless there is risk of intracranial bleeding, in which case a tissue valve is preferred	Ila	B	4-6,43,199,201,203
When there is annulus destruction and invasion, the mitral annulus is reconstructed and the valve prosthesis anchored to the ventricular muscle or to the reconstruction patch in a way that prevents leakage and pseudoaneurysm development beneath the prosthesis	Ila	B	43,203,218
9. Double-valve IE			
If the aortic root and aortic and mitral annuli are preserved after radical debridement, it is reasonable to implant mechanical or biologic valves, with the choice based on normal criteria	Ila	B	6,219,220
If there is aortic annulus destruction and invasion, and root reconstruction and replacement is required, an allograft or bioroot may be preferable to a prosthetic valved conduit, and if the mitral annulus shows invasion and destruction, it should be reconstructed to anchor the valve prosthesis to the ventricular muscle or to the annulus reconstruction patch to avoid leakage and pseudoaneurysm development beneath the prosthesis	Ila	B	124,126,219-224
Infection destroying the intervalvular fibrosa requires reconstruction of this structure, and it is preferable that surgeons taking on these cases master such techniques	Ila	C	219,223,225-229
10. Right-sided IE			
The primary objective of surgery for right-sided IE is radical debridement of infected vegetations and foreign material	I	B	57,136,201,230-242
Tricuspid valve repair should be attempted whenever possible	I	B	136,230-233,235,243,244

Recommendations	COR	LOE	References
1. Should regular synthetic vascular grafts or valveless allografts be used when the aorta must be replaced beyond the root?			
When distal ascending aorta, hemiarch, or arch replacement is required, a synthetic graft is the standard choice, but a valveless allograft is an alternative in an infected field for replacing the ascending aorta beyond the root	IIb	B	127,245
2. Should additional prostheses and vascular grafts not proved to be infected be removed and replaced?			
Inspection and removal of additional prostheses and vascular grafts, even if not proved to be infected, should be considered and is reasonable if the causative microorganism is <i>S. aureus</i> or fungus, provided that the added difficulty and risk is not prohibitive	IIa	C	127,246-249
3. When should permanent pacemaker systems be removed in patients undergoing surgery for IE?			
Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is indicated as part of the early management plan in patients with IE and likely infection of the device or leads	I	B	4,5,250-257
Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is reasonable in patients with right- or left-sided valvular IE caused by <i>S. aureus</i> or fungi, even without evidence of device or lead infection	IIa	B	4,5,250,252-258
Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is reasonable in patients undergoing surgery for valvular IE caused by any organism	IIb	C	4,5,256
4. Should patients with a known indication for a pacemaker receive a pacemaker system with epicardial leads when undergoing operation for active IE?			
At the time of surgery for IE, implantation of a new pacemaker system with epicardial leads may be considered when the patient is pacer dependent and has effective antimicrobial coverage	IIb	C	
5. Are there any safety concerns regarding use of mechanical valves in patients with IE?			
Mechanical valves should be avoided in patients with IE and evidence of intracranial bleeding or large brain infarcts, and in patients who are very sick and anticipated to have a prolonged postoperative course	I	C	164

6. Is there any role for local antimicrobials or antiseptics during surgery for IE?			
After completed debridement, generous irrigation of the surgical field with normal saline is recommended	I	C	
7. How should infected areas be drained?			
Whenever feasible, leaving infected areas open to the circulation or the pericardium is optimal from the standpoint of treating the infection	IIb	C	43
8. How should operative specimens be handled?			
Operative specimens should be secured for examination by the pathologist to determine presence of organisms and inflammatory activity	I	B	4,7,86,259
Operative specimens should be used for microbiologic and molecular testing to identify or confirm the pathogens and their sensitivity to antimicrobial therapy	I	A	4,7,58,86,259,260
9. What is the role of molecular testing with PCR in identifying pathogens?			
Whenever there is clinical suspicion of IE and doubt about the causative organism, molecular testing can be useful to identify and confirm the pathogens or causative organisms in the operative specimens	IIa	B	4,7,31,58,259-264
10. What postoperative antimicrobial treatment is required, and for how long should the patient be treated?			
When perioperative cultures and organism sensitivity are known, the antimicrobial regimen and duration of treatment are reconsidered and decided upon	I	B	3,4,7
After surgery for active IE, standard duration of postoperative intravenous antimicrobial treatment is 6 weeks, counted from the day of surgery, but regimen and duration may be modified and adjusted depending on the organism and its sensitivity to antimicrobials, treatment response, and pathology	IIa	B	3,4,7,265,266
For fungal IE, lifelong oral suppressive therapy is reasonable	IIa	B	3,4,7

Recommendations	COR	LOE	References
1. What is the need for follow-up and additional screening for infectious foci that could cause recurrent infection/IE?			
Primary infectious focus and microorganism portal of entry must be treated during or just after the IE episode, including follow-up and screening for underlying infectious foci and morbidities	I	B	3,4,7
IE caused by <i>Streptococcus gallolyticus</i> is an indication for colonoscopy within a reasonable time after operation	I	B	3,4,71,72,267-270
Patients with a history of injection drug use should be treated for their addiction	I	B	3,4,57,242
After surgery for IE, eradication of the pathogen is essential and should be verified by follow-up for 6 months with an infectious disease specialist	I	C	3
After valve surgery for IE, cure of the infection should be documented by echocardiogram, and the patient should follow up with a cardiologist	I	C	3
2. What is the risk of relapse and recurrent IE?			
Patients who have undergone surgery for IE should be informed about the increased risk of recurrent IE and the need for prophylaxis	I	B	3,179,200,271-277
3. Should surgical treatment be offered to injection drug users with IE?			
Normal indications for surgery are reasonable to apply to patients who are intravenous drug users. Decision-making must take the addiction into account, and management must include treatment of the addiction	IIa	C	3,4,7,57,201,238,242,278
4. Should surgical treatment be offered to patients with IE on dialysis?			
Normal indications for surgery are also reasonable to apply to patients on dialysis, but their additional comorbidity must be factored into their risk and outcome assessment	IIa	C	279-285
Patients with renal failure have shorter durability of bioprostheses and allografts because of early calcification, and this may be considered in the choice of an allograft or a bioprosthesis versus a mechanical valve	IIa	B	280,281
5. Should surgical treatment be offered to patients with IE and liver cirrhosis?			
Normal indications for surgery are reasonable to apply to patients with liver cirrhosis, but their additional comorbidity must be factored into their risk and outcome assessment	IIa	C	87,286,287
6. Who should get antibiotic prophylaxis for IE?			
Patients who have undergone surgery for IE constitute a high-risk group for recurrent IE and should be recommended for IE prophylaxis according to guidelines	IIb	B	3-5,88,288
7. How should patients with remote IE be managed?			
Normal indications for valve repair or replacement apply to patients with healed or remote IE, but conditions predisposing for IE should be diagnosed and treated	I	C	

Trends in IE Microbiology as a Percent of Total IE Cases From 2000 to 2011



Clinical and Echocardiographic Features That Suggest Potential Need for Surgical Intervention

Vegetation

Persistent vegetation after systemic embolization

Anterior mitral leaflet vegetation, particularly with size >10 mm*

≥ 1 Embolic events during first 2 wk of antimicrobial therapy*

Increase in vegetation size despite appropriate antimicrobial therapy*†

Valvular dysfunction

Acute aortic or mitral insufficiency with signs of ventricular failure†

Heart failure unresponsive to medical therapy†

Valve perforation or rupture†

Perivalvular extension

Valvular dehiscence, rupture, or fistula†

New heart block†‡

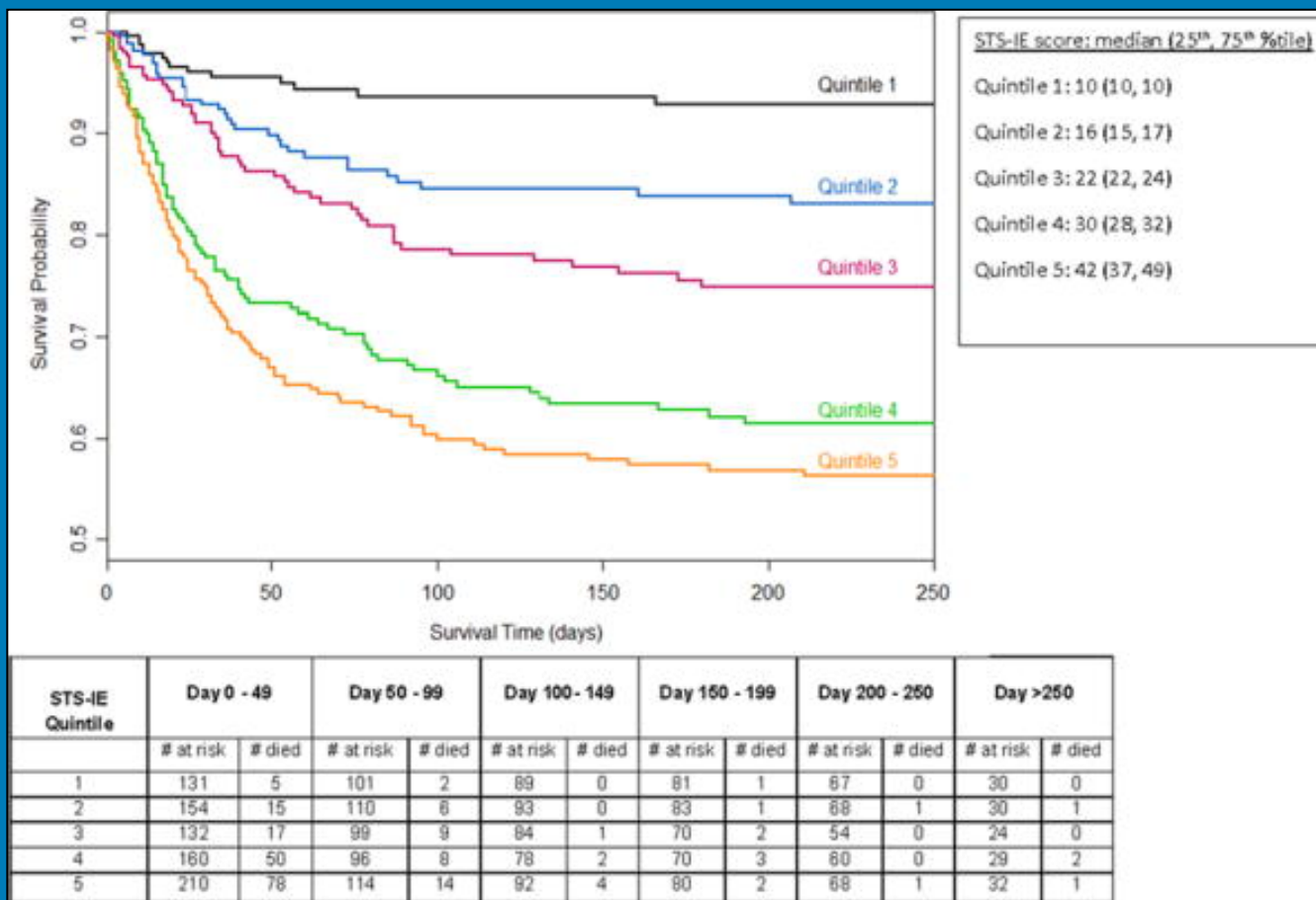
Large abscess or extension of abscess despite appropriate antimicrobial therapy†

Direct Evidence Supporting an Association Between Valve Surgery and Lower Mortality From Observational Studies

Study	Mortality	IE Group	PE vs SA
Lalani et al ¹⁰	In-hospital mortality	NVE	PE
Bannay et al ¹⁵	5-y mortality	NVE+PVE	PE
Kiefer et al ¹¹	In-hospital and 1-y mortality	CHF (NVE+PVE)	PE
Lalani et al ¹⁰	In-hospital mortality	Paravalvular complications (NVE)	SA
Bannay et al ¹⁵	5-y mortality	Intracardiac abscess (NVE+PVE)	SA
Lalani et al ¹⁰	In-hospital mortality	Systemic embolization (NVE)	SA
Bannay et al ¹⁵	5-y mortality	Systemic embolization (NVE+PVE)	SA
Lalani et al ¹⁰	In-hospital mortality	<i>S aureus</i> (NVE)	SA
Bannay et al ¹⁵	5-y mortality	CHF (NVE+PVE)	SA
Lalani et al ²⁵⁹	In-hospital and 1-y mortality	PVE with the highest propensity to undergo surgery	SA

Association Between Surgical Indications, Operative Risk, and Clinical Outcome in Infective Endocarditis: A Prospective Study From the International Collaboration on Endocarditis.

Survival by Society of Thoracic Surgeons (STS)-infective endocarditis (IE) quintile among IE patients with surgical indications.



Embolization in Infectious Endocarditis

- Indication for surgery has been 2 embolic events
- Greatest benefit of surgery is likely to be early
- Emboli independent predictor of mortality
- Use of prospective imaging in all patients for signs of embolization is controversial
- Anticoagulation in mechanical valve is usually withheld for 2 weeks
- No evidence of benefit with antithrombotic agents

Prognostic Factors in Surgical Treated IE

• Inadequate antibiotic treatment (agent, dose, duration)
• Resistant microorganisms, i.e. <i>Brucella spp.</i> , <i>Legionella spp.</i> , <i>Chlamydia spp.</i> , <i>Mycoplasma spp.</i> , <i>Mycobacterium spp.</i> , <i>Bartonella spp.</i> , <i>Coxiella Burnetii</i> , fungi
• Polymicrobial infection in an IVDA
• Empirical antimicrobial therapy for BCNIE
• Periannular extension
• Prosthetic valve IE
• Persistent metastatic foci of infection (abscesses)
• Resistance to conventional antibiotic regimens
• Positive valve culture
• Persistence of fever at the seventh postoperative day
• Chronic dialysis