Endocarditis is an inflammation of the endothelial lining of the heart. It is usually focal and commonly occurs at points of endocardial injury. The mitral and aortic valves are the most common sites of involvement.

- Most sites of endocardial injury become seeded with bacteria during episodes of transient bacteremia and thus develop into infective endocarditis.
- The initial symptoms are often vague—low-grade fever, malaise, and weakness.
- Manifestations can vary from direct structural cardiac injury to conduction system disturbances, embolic phenomena, and cardiogenic or septic shock.
- Suspicion of infective endocarditis should be raised by the presence of well-known risk factors, such as acquired or congenital valvular or structural heart disease, a prosthetic valve, implanted medical devices, injection drug use, and a previous history of endocarditis.
- Laboratory testing is often not useful for the emergency physician, but at least three sets of blood cultures performed over time are critical for the diagnosis of infective endocarditis, as well as for guiding subsequent therapy.
- The most useful initial diagnostic test is echocardiography.
- In an acutely ill patient, prompt resuscitation, antibiotics, and surgical consultation are imperative.
- In a stable patient with subacute disease, time until initiation of antibiotic therapy is less critical than performance of serial blood cultures.
- Nearly all patients with infective endocarditis require hospital admission. Only the most stable patients with no complications in whom the diagnosis of infective endocarditis is being entertained but not confirmed may be discharged with very close follow-up care.
- Despite medical advances, the overall mortality for both native valve and prosthetic valve infective endocarditis still ranges from 20% to 25%.1
- Prevention of disease is most important. In 2007 the American Heart Association issued revised guidelines for antibiotic prophylaxis in patients at risk for endocarditis.

**Epidemiology**

Endocarditis is an inflammation of the endothelium, or inner lining, of the heart or heart valves (or both). The disrupted endothelium is very susceptible to seeding with infectious agents such as bacteria, viruses, and fungi, a condition known as infective endocarditis (IE). Recognized by medical science for more than 400 years, IE remains an illness that is difficult to diagnose and treat and still results in significant morbidity and mortality.

Over the last 30 years, published reports regarding the overall incidence of IE have conflictingly cited both a stable incidence and a rising incidence.1-3 Mortality ranges from 5% to 50% or higher. The reason for such variation in the statistics is that IE is a diverse and evolving disease entity—one that is strongly influenced by the characteristics of both the human and microbial populations being studied (Table 62.1).

In the developed world, IE has undergone a remarkable transformation over the last century. In the developing world, however, it has remained rather unchanged. Much of this difference is a result of the influence of advances in health care (e.g., antibiotics, disease prevention, medical devices, the resulting longevity of populations), as well as the complications that arise from these advances (e.g., nosocomial infections and resistant organisms).4,5

Unfortunately, the tremendous advances made in health care have not translated into the gains that we have seen in other infectious diseases in the last 50 to 80 years. Untreated, IE has a mortality of nearly 100%. When treated, however, IE is still associated with a mortality rate of 20% to 25%.5 The overall incidence of IE in the developed world has remained unchanged.4 Why has the advent of antibiotics, advanced critical care and surgical techniques, and medical devices such as prosthetic valves not made a difference in this statistic? There are several reasons.

First, with a low prevalence, no pathognomonic signs or symptoms, and no single diagnostic front-line test, IE remains difficult to diagnose. Therefore, many cases are missed or diagnosed only when the disease is advanced. Second, despite the effective control of rheumatic heart disease in the developed world, new risk factors have arisen to fill the void. Degenerative heart disease in the growing elderly population has replaced rheumatic fever as the major cause of valvular disease. The same intravascular medical devices that have improved survival for patients (e.g., valvular prosthetics, cardiac pacemakers, long-term indwelling vascular catheters)
The term endocarditis literally means inflammation of the inner lining or endothelium of the heart or lining of heart valves (or both). Local or systemic stressors, such as trauma, blood-borne contaminants (e.g., talc from injection drug use), inflammation, and abnormal blood turbulence, induce injury to the endothelium. Clinically relevant endocarditis results from the formation of a fibrin and platelet cap on the area of altered surface endothelium. Most commonly, a sterile cap forms at a site of endothelial injury. IE occurs when microbes adhere to these sites of sterile endothelial injury during transient periods of bacteremia, fungemia, or viremia. Colonization occurs, followed by microbial multiplication and growth of each cap into a vegetation (Figs. 62.1 and 62.2). Because of their direct contact with the bloodstream, these infections cause a continuous, albeit low-level presence of microbes in the blood. The clinical manifestations of endocarditis are quite varied as a result of immunologic, infectious, and embolic predispose them to the development of IE (regardless of whether they have had IE in the past). Third, the number of patients at risk for IE has increased—the elderly, patients receiving critical care, and immunocompromised patients (because of acquired immunodeficiency syndrome, diabetes mellitus, end-stage renal disease, chemotherapy, and other reasons). Risky social behavior, such as body piercing and injection drug use, is practiced more today than in the early 20th century. Finally and most concerning of all, burgeoning antibiotic resistance is making treatment of IE more challenging and sometimes unachievable.6

Because prevention and early diagnosis are the keys to reducing the morbidity and mortality associated with IE, emergency physicians (EPs) must play an important role in this process. Vigilance is key. EPs must consider the diagnosis when patients with risk factors for IE are seen in the emergency department (ED) with subtle symptoms. EPs must provide education to patients who are at high risk for IE and must provide prophylaxis for IE when warranted.

### Table 62.1 Statistics for Infective Endocarditis (IE) in the Developed World

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age of IE patients in the preantibiotic era</td>
<td>30-40 yr</td>
</tr>
<tr>
<td>Median age of IE patients in the antibiotic era</td>
<td>47-69 yr</td>
</tr>
<tr>
<td>Mean male-to-female ratio</td>
<td>1.7-2.0:1</td>
</tr>
<tr>
<td>Incidence of community-acquired native valve IE (western Europe/United States)</td>
<td>1.7-6.2 cases per 100,000 person-years</td>
</tr>
<tr>
<td>Incidence of IE in persons with known mitral valve prolapse</td>
<td>100 cases per 100,000 person-years</td>
</tr>
<tr>
<td>Incidence of IE in injection drug users</td>
<td>150-2000 cases per 100,000 person-years</td>
</tr>
<tr>
<td>Prosthetic valve IE</td>
<td>7-25% of all cases of IE</td>
</tr>
<tr>
<td>Overall mortality for both native and prosthetic valve IE</td>
<td>20-25%</td>
</tr>
<tr>
<td>Mortality with viridans group streptococci and Streptococcus bovis IE</td>
<td>4-16%</td>
</tr>
<tr>
<td>Mortality with enterococci IE</td>
<td>15-25%</td>
</tr>
<tr>
<td>Mortality with Q fever IE</td>
<td>5-37%</td>
</tr>
<tr>
<td>Mortality with Staphylococcus aureus IE</td>
<td>25-47%</td>
</tr>
<tr>
<td>Mortality with Pseudomonas aeruginosa, Enterobacteriaceae, or fungal IE</td>
<td>&gt;50%</td>
</tr>
</tbody>
</table>


### PATHOPHYSIOLOGY

Fig. 62.1 Large vegetations (circles) at the edge of this mitral valve (black arrow). Chordae tendineae (white arrow) connect the mitral valve to papillary muscles in the left ventricle. (Courtesy Charles C. Marboe, MD.)

Fig. 62.2 Large vegetation (circle) in a patient with endocarditis. The short arrow indicates the endocardial surface of the dilated left atrium, and the long arrow indicates the edge of the mitral valve and chordae tendineae. (Courtesy Charles C. Marboe, MD.)
processes. It is this variation in manifestations that often makes endocarditis difficult to identify.

**MICROBIOLOGY OF INFECTIVE ENDOCARDITIS**

Although the microbiology of IE can predict the course of a patient’s illness and guide therapy, the actual infecting organism is rarely known to the EP. The EP needs to know the microbes that cause IE (Box 62.1) and the local resistance patterns to make sound choices regarding empiric antibiotic treatment regimens. This section discusses the organisms most commonly associated with IE. Certain patient characteristics and clinical scenarios are associated with particular microorganisms (Table 62.2). These scenarios may guide the EP’s choice of empiric antibiotics; specific regimens are discussed later in this chapter (see Table 62.4).

**BOX 62.1 Microorganisms That Cause Infective Endocarditis (Approximate Percentage)**

<table>
<thead>
<tr>
<th>Most Common</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus aureus (31%)</td>
<td></td>
</tr>
<tr>
<td>Viridans group streptococci (17%)</td>
<td></td>
</tr>
<tr>
<td>Enterococci (11%)</td>
<td></td>
</tr>
<tr>
<td>Staphylococcus epidermidis (11%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Less Common</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Streptococcus bovis (7%)</td>
<td></td>
</tr>
<tr>
<td>Streptococcus pneumoniae and other streptococci (5%)</td>
<td></td>
</tr>
<tr>
<td>Pseudomonas aeruginosa (&lt;3%)</td>
<td></td>
</tr>
<tr>
<td>Culture-negative bacteria (12%):</td>
<td></td>
</tr>
<tr>
<td>Abiotrophia spp.</td>
<td></td>
</tr>
<tr>
<td>Bartonella spp. (usually henselae or quintana)</td>
<td></td>
</tr>
<tr>
<td>Brucella spp. (usually melitensis or abortus)</td>
<td></td>
</tr>
<tr>
<td>Chlamydia spp. (usually psittaci)</td>
<td></td>
</tr>
<tr>
<td>Coxiella burnetii (Q fever)</td>
<td></td>
</tr>
<tr>
<td>HACEK group of gram-negative bacteria</td>
<td></td>
</tr>
<tr>
<td>Legionella spp.</td>
<td></td>
</tr>
<tr>
<td>Tropheryma whippelii</td>
<td></td>
</tr>
<tr>
<td>Fungi (2%)</td>
<td></td>
</tr>
</tbody>
</table>

*Haemophilus species, Actinobacillus actinomycetemcomitans, Cardiobacterium hominis, Eikenella corrodens, and Kingella kingae.*


**BACTERIA**

**Viridans Group Streptococci**

*Streptococcus viridans,* formerly a species name, is actually a group of gram-positive cocci. This group has been the most common cause of IE, although more recent case series have shown that *Staphylococcus aureus* may now be more common. These streptococci usually seed previously damaged cardiac tissue. The clinical findings are usually more insidious, however, with patients experiencing malaise, weakness, and low-grade fever.

**Staphylococcus aureus**

Studies have now identified *S. aureus* rather than the viridans group of streptococci as the most common cause of IE. *S. aureus* can infect normal valvular endothelium—that is, endothelium without antecedent damage or disease—and usually causes aggressive valve destruction. It is associated with injection drug use, as well as with prosthetic valve endocarditis that occurs more than 1 month after surgery.

Over the last decade, the story of *S. aureus* and *S. aureus* IE has become increasingly complicated with the emergence of methicillin-resistant *S. aureus* (MRSA), as well as the subsequent identification of community-associated (CA-MRSA) and hospital-associated (HA-MRSA) subtypes. CA-MRSA has a tendency to affect previously healthy individuals but has a drug sensitivity pattern more favorable than that of HA-MRSA. HA-MRSA tends to affect the infirm (hospitalized, nursing home, elderly, preterm, and immunocompromised patients) and has a limited sensitivity pattern. A review of cases of native valve IE caused by these organisms reveals a higher mortality rate with HA-MRSA (37%) than with methicillin-sensitive *S. aureus* and CA-MRSA (23% and 13%, respectively).*

**Staphylococcus epidermidis**

*S. epidermidis* is an organism associated with prosthetic valve endocarditis, especially that occurring within 1 month of surgery. The course of IE attributable to this organism is usually aggressive.

**Streptococcus bovis**

Infective endocarditis caused by *S. bovis* occurs more commonly in the elderly and often originates from a gastrointestinal (GI) source. It is commonly associated with GI polyps, inflammatory bowel disease, and GI malignancy.

**Streptococcus pneumoniae**

*S. pneumoniae* is an aggressive organism that frequently causes an acute, fulminant illness. It can infect normal heart valves, most often the aortic valve, with a high risk for the development of perivalvular abscesses or pericarditis. Pneumococcal endocarditis can occur in association with pneumococcal pneumonia and meningitis in a grouping called the Austrian triad.

**Enterococci**

Enterococci are normal flora of the GI tract and, occasionally, the anterior urethra. IE caused by one of these organisms usually runs a subacute course, but cure is often difficult because of the bacteria’s intrinsic resistance to antibiotics. The
Table 62.2 Characteristics of Patients with Infectious Endocarditis and Associated Microorganisms

<table>
<thead>
<tr>
<th>CHARACTERISTIC</th>
<th>ORGANISM</th>
<th>COURSE/FACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community-acquired IE involving a native valve</td>
<td>Viridans group streptococci</td>
<td>Indolent gram-positive bacteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most common cause of native valve endocarditis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually seeds damaged cardiac tissue</td>
</tr>
<tr>
<td></td>
<td>Staphylococcus aureus</td>
<td>Aggressive gram-positive bacterium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Some new case series identify S. aureus as the new most common cause of IE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can seed normal valves</td>
</tr>
<tr>
<td>Prosthetic valve IE &lt; 1 mo after surgery</td>
<td>Staphylococcus epidermidis</td>
<td>Aggressive gram-positive bacterium</td>
</tr>
<tr>
<td>Prosthetic valve IE &gt; 1 mo after surgery</td>
<td>S. aureus</td>
<td>Aggressive gram-positive bacterium</td>
</tr>
<tr>
<td>Elderly patient</td>
<td>Enterococci</td>
<td>Gram-positive bacteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually a subacute manifestation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Difficult to treat because of intrinsic antibiotic resistance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GI flora</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typically affects older men after genitourinary manipulation or middle-aged women after obstetric procedures</td>
</tr>
<tr>
<td>Elderly patient with a GI process</td>
<td>Streptococcus bovis</td>
<td>Gram-positive bacterium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be aggressive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Associated with inflammatory bowel disease, colonic polyps, colon cancer</td>
</tr>
<tr>
<td>Injection drug user</td>
<td>S. aureus</td>
<td>Aggressive gram-positive bacterium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Most common cause of tricuspid valve IE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually multiple-valve involvement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Often oxacillin resistant</td>
</tr>
<tr>
<td></td>
<td>Viridans group streptococci</td>
<td>Indolent gram-positive bacteria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually cause left-sided IE in injection drug users</td>
</tr>
<tr>
<td></td>
<td>Pseudomonas aeruginosa</td>
<td>Aggressive gram-negative bacterium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually multiple-valve involvement</td>
</tr>
<tr>
<td></td>
<td>Fungi</td>
<td>Patient usually very ill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Large vegetations often embolize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Surgical intervention commonly needed</td>
</tr>
<tr>
<td></td>
<td>P. aeruginosa</td>
<td>Aggressive gram-negative bacterium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rare</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Usually multiple-valve involvement</td>
</tr>
</tbody>
</table>

GI, Gastrointestinal; IE, infective endocarditis.

*Data from Baddour LM, Wilson WR, Bayer AS, et al, for the Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease; Council on Cardiovascular Disease in the Young; Councils on Clinical Cardiology, Stroke, and Cardiovascular Surgery and Anesthesia; American Heart Association; Infectious Diseases Society of America. Infective endocarditis: diagnosis, antimicrobial therapy, and management of complications. A statement for healthcare professionals from the Committee on Rheumatic Fever, Endocarditis, and Kawasaki Disease, Council on Cardiovascular Disease in the Young, and the Councils on Clinical Cardiology, Stroke, and Cardiovascular Surgery and Anesthesia, American Heart Association; endorsed by the Infectious Diseases Society of America. Circulation 2005;111:e394-434.

relapse rate is high after standard therapy. Typically, this problem occurs in older men after genitourinary manipulation and in middle-aged women after obstetric procedures.

**Pseudomonas aeruginosa**

A rare cause of IE, *P. aeruginosa* is an aggressive gram-negative bacterium. IE caused by this organism usually complicates the course of critically ill patients and injection drug users.

**Culture-Negative Bacteria**

The culture-negative bacteria group infrequently causes IE. These bacteria are characterized as culture negative because they either grow slowly in routine media, require special media to grow, or cannot be cultured. If clinical suspicion exists, the clinician must ask that blood cultures be held for a prolonged incubation period (14 to 21 days), request special culture media, or use the serologic and polymerase chain reaction assays available for some of these
bacteria. A list of culture-negative bacteria is provided in Box 62.1.

The HACEK bacteria (Haemophilus species, Actinobacillus actinomycetemcomitans, Cardiobacterium hominis, Eikenella corrodens, and Kingella kingae) are normal bacteria that commonly colonize the human oropharynx.

**Fungi**

Fungi are rarely a cause of endocarditis, but fungal IE has high mortality. Candida species are responsible for most cases of fungal IE. Aspergillus species are also seen. Fungal IE tends to occur in patients with cardiac abnormalities, medical devices (prosthetic valves, long-term indwelling vascular catheters), some level of compromised immunity (human immunodeficiency virus, malignancy, organ transplantation), and injection drug use.9 Fungal IE usually produces large vegetations and is an indication for surgical intervention.

**Presenting Signs and Symptoms**

IE can vary greatly in the severity of its manifestations. Depending on the extent of the injury, location of the injury, microorganism involved, and comorbid conditions in the patient, IE can be an insidious chronic or subacute disease or an aggressive, rapidly debilitating process. Recent prospective cohort data from an international multicenter study have revealed that the acute manifestation is becoming more common—perhaps because of the increasing prevalence of S. aureus IE.9

The diagnosis of IE is challenging in both its insidious and acute forms. When the findings are subtle, a more benign diagnosis, such as a nonspecific viral syndrome, may be blamed for the illness. When the manifestation is acute and critical, a diagnosis in accordance with the syndrome (e.g., congestive heart failure [CHF], sepsis, heart block, stroke) may be made—without failure to identify the underlying cause (endocarditis). In both scenarios there is continued morbidity and possibly mortality.

EPs must maintain high clinical suspicion in situations associated with IE. Patients at high risk for IE are listed in Box 62.2. In such patients, sepsis, embolization, or cardiac failure or shock should warrant an evaluation for endocarditis. By understanding the pathophysiology of this disease, the clinician can predict the signs and symptoms that might be seen with IE.

** classic triad**

The triad consisting of fever, heart murmur, and anemia has classically been ascribed to the diagnosis of IE. Unfortunately, the sensitivity and specificity of these findings for endocarditis are poor. The clinician must combine these findings with high-risk patient characteristics (see Box 62.2).

**Organ-Specific Clinical Findings**

Most commonly, patients with IE have symptoms of malaise and fatigue in the setting of a low-grade fever. Most of this probably reflects the immunologic response to constant bacteremia. Patients may complain of generalized weakness with anorexia and weight loss. Without high clinical suspicion, a nonspecific viral syndrome may often be diagnosed.

**Box 62.2 Risk Factors for Infective Endocarditis**

| Acquired or congenital valvular and structural heart disease, including mitral valve prolapse, rheumatic heart disease, and hypertrophic cardiomyopathy |
| Prosthetic valves, including bioprosthetic devices |
| Implantable medical devices (cardiac pacemakers, long-term indwelling vascular catheters, implantable defibrillators) |
| Injection drug use |
| Poor dental hygiene |
| Long-term hemodialysis |
| Diabetes mellitus |
| Previous history of endocarditis |
| Immunocompromised states |


**vascular signs and symptoms**

Septic embolization of the vasa vasorum (blood vessels that feed large blood vessels) can lead to the development of mycotic aneurysms in any of the body’s larger arteries. Patients can exhibit pain, lightheadedness, altered mental status, and even syncope from the vascular insufficiency or hemorrhage that may occur at any of the sites of involvement.

The signs and symptoms that may be seen with involvement of specific vascular sites are as follows:

- Central nervous system (CNS) arteries—headache, focal neurologic deficits, confusion
- Sinus of Valsalva—pleuritic chest pain, muffled heart tones
- Hepatic artery—right upper quadrant pain, hematemesis
- Splenic artery—abdominal pain, intraabdominal hemorrhage
- Renal arteries—flank pain, hematuria
- Intestinal arteries—abdominal pain, intraabdominal hemorrhage, melena, hematochezia

**Cardiac Signs and Symptoms**

Cardiac symptoms of IE include chest pain, shortness of breath, lightheadedness, and even syncope. These symptoms can result from a variety of heart-specific processes.

Valvular damage can lead to valvular insufficiency (and murmur), which may progress to CHF and even frank cardiogenic shock, especially with left-sided valve involvement. With right-sided valve endocarditis, right heart failure with hepatosplenomegaly and peripheral edema might be evident.

Intracardiac abscess formation causes clinical compromise in a number of ways, depending on the cardiac structure involved. Erosion into the conduction system can lead to all manner of heart blocks, including complete heart block. Involvement of the valvar annulus can result in valvular incompetence and heart failure or may lead to erosion into the pericardial space and cardiac tamponade. Cardiac wall abscess can give rise to septal or free wall rupture or to valvular compromise as a result of papillary muscle rupture.

Emboliology of endocarditis vegetations to the coronary arteries can cause diffuse myocarditis via diffuse seeding of the myocardium. Myocardial infarction may occur through...
direct intraluminal embolization and coronary artery occlusion or through embolic seeding of the coronary vasa vasorum and the formation of coronary mycotic aneurysms.

**Pulmonary Signs and Symptoms**
Pulmonary complaints need not be present in patients with IE. Common pulmonary symptoms are dyspnea and cough. Pulmonary complaints related to embolization may accompany right-sided IE—tricuspid or pulmonic valve endocarditis. Patients may have pneumonia secondary to pulmonary septic emboli. Ventilation-perfusion mismatching may develop as a result of pulmonary embolization. Left-sided endocarditis can lead to pulmonary congestion secondary to cardiac failure and acute pulmonary edema.

**Neurologic and Psychiatric Signs and Symptoms**
Endocarditis can be accompanied by myriad neurologic and psychiatric signs and symptoms. They can be a result of the systemic effects of hypotension and sepsis or a direct result of focal CNS embolization. Clinical findings may include confusion, complex changes in behavior, headache, seizure, stroke, or coma. The diagnosis of IE can be hard to make because of the large list of differential diagnoses for these symptoms.

**Ophthalmologic Signs and Symptoms**
The eye is not immune to endocarditis. Both embolic and immune phenomena can affect the optic nerves, ophthalmic vessels, conjunctivae, and retina. Initial complaints may include painless conjunctival hemorrhages, visual field cuts, and even monocular blindness. Emboli can cause infarction of the ophthalmic or retinal vessels and lead to loss of vision. Hemorrhages with pale cotton-wool centers known as Roth spots can be visualized on the retina (Fig. 62.3). EPs should be aware that these spots are not pathognomonic for IE but rather, if seen, should raise suspicion for this disease. Painless subconjunctival hemorrhages (Fig. 62.4), or petechiae involving the conjunctivae, can also be present and again are not specific.

**Hematopoietic Signs and Symptoms**
Weakness and fatigue can result from anemia, which can be associated with IE. Usually, the anemia is normocytic and mild. IE can also stimulate an immune response marked by leukocytosis and splenomegaly.

**Gastrointestinal Signs and Symptoms**
Nausea and vomiting are very nonspecific symptoms. In a patient with IE, these symptoms may accompany complications such as myocardial infarction, pericardial edema, and processes that increase intracranial pressure. Abdominal pain in patients with IE may be a manifestation of a nonspecific ileus, mesenteric ischemia from mesenteric emboli, or mycotic aneurysms of the splanchnic vasculature.

**Renal Signs and Symptoms**
Emboli to the kidneys can result in abscess formation, ischemia, and infarction. The resultant flank pain, pyuria, or hematuria (or any combination of the three) may easily be misdiagnosed as urolithiasis or pyelonephritis. Hematuria can also be a manifestation of glomerulonephritis from immune complex deposition related to IE.

**Dermatologic Signs and Symptoms**
The skin can give great clues to the presence of IE. Classic findings are Janeway lesions, Osler nodes, and splinter hemorrhages. Janeway lesions are small, painless hemorrhages with a macular or slightly nodular character (Fig. 62.5). They are found on the thenar and hypothenar eminences of the palms and soles. The histologic findings are generally consistent with septic microemboli. Bacteria have been cultured from these lesions. Janeway lesions are usually present for days to
Splinter hemorrhages are linear petechiae visible on the nail beds of affected patients (Fig. 62.7). They do not blanch when pressure is applied to the nail and are seen better if a bright light is shone directly onto the distal tip of the digit.

**DIFFERENTIAL DIAGNOSIS AND MEDICAL DECISION MAKING**

**DIFFERENTIAL DIAGNOSIS**

Because of the many clinical manifestations of IE, the list of differential diagnoses is overwhelmingly large. Broad areas include infectious and febrile illnesses, as well as cardiovascular, neurologic, psychiatric, GI, renal, dermatologic, and immunologic disorders (Box 62.3). Most interestingly, IE can lead to manifestations that are diagnoses; the EP must think past that initial diagnosis and identify IE as the underlying cause. For example, a cerebrovascular accident or myocardial infarction may be secondary to the embolization or mycotic aneurysms of IE; this fact is important because therapy must also focus on treating the IE.

The most common illness in the differential diagnosis list for IE is febrile illness of any source. Viral syndromes, pneumonia, and urinary tract infections may cause fever, weakness, behavioral abnormalities, and even hemodynamic instability.

The most life-threatening entities are aortic catastrophes, myocardial infarction (with or without acute valve failure), complete heart block, massive pulmonary embolism, cerebrovascular accident, and sepsis.

As mentioned frequently in this chapter, high clinical suspicion guided by knowledge of risk factors (see Box 62.2) is the key to including IE in this long, complex list of differential diagnoses.
Chapter 62
Endocarditis

Contributing to the complexity of IE is the fact that there is neither a single rapid test to diagnose the disorder nor any routine ancillary test that hints at the diagnosis. Some physical findings might clue the EP to this diagnosis, but they are nonspecific. For the EP, the most important tool for diagnosing IE is clinical suspicion. Elements of the history known to identify patients at high risk for endocarditis and may represent vessel damage from vasculitis or microemboli. (A and B, Courtesy Marc E. Grossman, MD, FACP; C, used with permission from Johns Hopkins University and obtained online from www.vasculitis.med.jhu.edu/typesof/polyangiitis.html.)

**Medical Decision Making**

The most accepted diagnostic schema for IE is the modified Duke criteria (Box 62.4). Unfortunately for the EP, this approach relies heavily on blood culture and echocardiography, the results of which are rarely available to EPs at the outset of care. With recent efforts to bring ultrasonography skills to the ED bedside, echocardiography may become more readily available as an initial evaluation tool, but for now, the procedure requires cardiology consultation and is often not available during the first few hours of care.

According to the modified Duke criteria (see Box 62.4), an echocardiogram positive for IE along with presence of three minor criteria would allow the EP to actually make a “definite diagnosis” of IE in the ED. In all other cases, an echocardiogram positive for IE enables the diagnosis to be “possible IE” as the clinician awaits the results of blood cultures or serologic analysis. It must be emphasized, however, that normal
**Fig. 62.8** Diagnostic algorithm for the emergency department management of patients in whom infective endocarditis (IE) is suspected. *Echocardiography can be performed via either the transthoracic (TTE) or transesophageal (TEE) technique. TEE is more invasive but is more sensitive for detecting vegetations and complications of IE, such as perivalvular abscesses; it is recommended for prosthetic valves; for situations in which optimal visualization by TTE will be difficult, such as emphysema and morbid obesity; for high suspicion of IE but normal TTE findings; and for high suspicion of a complication of IE, such as perivalvular abscess. Normal findings with either technique do not exclude IE if clinical suspicion is high. Echocardiograms can be repeated in an attempt to identify problems such as vegetations and abscesses that may not be noted initially. **ABCs**, **Airway**, breathing, and circulation; **CBC**, complete blood count; **CHF**, congestive heart failure; **CVA**, cerebrovascular accident; **ECG**, electrocardiogram; **ESR**, erythrocyte sedimentation rate; **ICU**, intensive care unit.
Endocarditis is recommended in patients with suspected infective endocarditis (IE) into one of three categories as follows: the major and minor criteria are listed below.

A diagnosis of “definite” endocarditis is made in a patient with one of the following:
- Histologic and/or microbiologic evidence of infection at surgery or autopsy
- 2 major criteria
- 1 major criterion and 3 minor criteria
- 5 minor criteria

A diagnosis of “possible” endocarditis is made in a patient with one of the following:
- 1 major criterion and 1 minor criterion
- 3 minor criteria

A diagnosis of endocarditis is “rejected” in a patient with one of the following:
- Negative findings at surgery or autopsy in a patient who received antibiotic therapy for ≤4 days
- A firm alternative diagnosis
- Resolution of illness with antibiotic therapy for ≤4 days
- Failure to meet the criteria for “possible” endocarditis

**Major Criteria**

**Blood Culture Results Positive for Infective Endocarditis**

1. Typical microorganisms causing IE from two separate blood cultures in the absence of a primary focus:
   - Viridans group streptococci
   - *Streptococcus bovis*
   - HACEK group of bacteria
   - Community-acquired *Staphylococcus aureus* or *Enterococcus*

2. Persistently positive blood culture results, defined as recovery of a microorganism consistent with IE from one of the following:
   - Blood culture specimens obtained more than 12 hours apart
   - All of 3 or a majority of 4 or more separate blood culture specimens, the first and last of which have been obtained at least 1 hour apart

**Minor Criteria**

**Predisposition:** Predisposing heart condition or intravenous drug use

**Fever:** Body temperature > 38.0°C (100.4°F)

**Vascular phenomena:** Major arterial emboli, septic pulmonary infarcts, mycotic aneurysms, intracranial hemorrhage, conjunctival hemorrhages, Janeway lesions

**Immunologic phenomena:** Glomerulonephritis, Osler nodes, Roth spots, rheumatoid factor

**Microbiologic evidence:** Positive blood culture result but not meeting the major criteria as noted above (excluding a single positive culture result for coagulase-negative staphylococci and organisms that do not cause endocarditis) OR serologic evidence of active infection with an organism consistent with IE.

**Diagnosis of Endocarditis**

Glomerulonephritis, Osler nodes, immunologic phenomena are nearly always present in patients with IE. Major and minor criteria are listed below.

**Major Criteria**

- Evidence of Endocardial Involvement
  1. Positive echocardiographic results for IE:
     - *Transesophageal echocardiography* recommended in patients who have prosthetic valves, who have been rated as having at least “possible IE” by clinical criteria, or who have complicated IE (paravalvular abscess).
     - *Transthoracic echocardiography* recommended as the first test in other patients.

2. New valvular regurgitation. An increase or change in a pre-existing murmur is not sufficient evidence.

**Minor Criteria**

**Predisposition**

**Fever**

**Vascular phenomena**

**Immunologic phenomena**

**Microbiologic evidence**

**DIAGNOSTIC TESTING**

Many diagnostic tests are available to help the EP evaluate and manage patients with possible IE. Many of these tests assist in identifying the complications of this disease process.

**LABORATORY TESTS**

Though not diagnostic when performed alone, some laboratory tests can be useful in diagnosing endocarditis and managing patients in the ED.

The complete blood cell count is less useful than one might think. Leukocytosis is present only in some cases. Normochromic normocytic anemia may be seen.

An elevated erythrocyte sedimentation rate or C-reactive protein value can be a good though nonspecific clue. Both findings are markers for an ongoing inflammatory process and are nearly always present in patients with IE.

Urine analysis often shows proteinuria and sometimes hematuria. Proteinuria may occur as a result of the immunologic effects of endocarditis. Chronic infection or inflammation leads to the formation of immune complexes and their deposition in
the glomeruli. Depending on the duration of this illness, the patient may have glomerulonephritis and renal insufficiency.

Renal function can be affected in patients with IE. A serum creatinine measurement is not useful for the diagnosis of IE, but it is for its management. Antibiotic dosing and the use of intravenous contrast–enhanced computed tomography (CT) are dependent on a patient’s renal function.

Less useful for the EP but part of the modified Duke criteria for IE are serologic tests. Rheumatoid factor may occasionally be found in patients with IE, particularly those with long-standing, indolent cases. Serologic assays can detect the presence of bacteria such as Coxiella, Brucella, Bartonella, Legionella, and Chlamydia. Polymerase chain reaction testing for specific DNA or RNA from blood, urine, or surgically excised tissue can be performed when the potential pathogen is slow growing or cannot be cultured by conventional methods.

MICROBIOLOGY
Perhaps the most useful test for the diagnosis and management of IE is serial blood cultures. Unfortunately, the results of cultures are often not available to the EP. Three sets of blood culture specimens should ideally be collected before the initiation of antibiotics at intervals of at least 30 minutes and over a period of 3 to 6 hours. There is little increased culture yield beyond three sets of blood cultures as long as they are obtained before the administration of antibiotics.

IE results in a constant, low-grade bacteremia. Therefore, it is not necessary to obtain blood culture specimens only during temperature spikes. Serial blood culture specimens obtained over a period of hours to days (in the absence of antibiotic therapy) should all yield positive results as long as at least 10 mL of blood per culture bottle is collected. In the interest of identifying endocarditis caused by more fastidious organisms, it is recommended that blood cultures be held for 14 to 21 days before being labeled negative.

The EP must remember that antecedent antibiotic treatment can also result in negative blood culture results, so the history should include questions about such treatment. In a stable patient with a history of antecedent antibiotic therapy, serial blood culture specimens should be collected over a longer time (even days) before initiation of antibiotic therapy for IE.

The caveat to the timing of serial blood sampling for culture is that withholding antibiotics should be the strategy in a stable patient who has no other indications for antibiotics. In an unstable or acutely ill patient, the three sets of blood culture specimens should be obtained over a period of 5 to 20 minutes and then antibiotics given as early as possible.

ELECTROCARDIOGRAPHY
Acquisition of an electrocardiogram (ECG) is often prompted by abnormalities in vital signs, initial symptoms, or clinical instability. If the EP suspects IE, an ECG must be performed. Abnormalities found on the ECG can be caused by endocarditis, but as with other findings for this diagnosis, these abnormalities are nonspecific. The pathologic findings that can be associated with endocarditis are acute myocardial infarction (secondary to coronary artery involvement), complete heart block, atrioventricular block, and bundle branch blocks. Infarction can occur as a result of direct embolization to the coronary arteries or coronary mycotic aneurysm formation. Conduction abnormalities can arise from direct extension of infection to the conduction system. Most commonly, the ECG in patients with endocarditis is normal or reveals a sinus tachycardia.

ECHOCARDIOGRAPHY
Echocardiography is the most important diagnostic tool available to the EP for the early identification of endocarditis and must be performed rapidly in all cases of suspected IE. It is one of the major criteria for the diagnosis of IE according to the modified Duke criteria (see Box 62.4 for echocardiographic findings that are diagnostic of IE) (Fig. 62.9). In addition, echocardiography allows assessment of disease severity, complications, prognosis, and the need for surgical therapy. It is therefore a critical component in the initial assessment of a patient suspected of having IE.

Transthoracic Echocardiography
Easily done at the bedside, transthoracic echocardiography (TTE) is recommended as the initial imaging modality. It can identify valvular damage and valvular vegetations, as well as assess cardiac function and pulmonary pressure. Its limitations lie in the assessment of patients with a prosthetic valve or intracardiac hardware.

Transesophageal Echocardiography
Although it requires more preparation and is more invasive than TTE, transesophageal echocardiography (TEE) has greater sensitivity and specificity (Table 62.3). It can visualize smaller vegetations, as well as myocardial involvement such as abscesses and prosthetic valve vegetations. TEE is recommended for patients with the following findings:

- The TTE result is negative, but clinical suspicion for IE is high.
- The TTE result is positive, but there is concern for the presence of a high-risk complication of IE, such as large or mobile vegetations, significant valvular insufficiency, or a suggestion of perivalvular extension.
- The TTE result is suboptimal because of, for example, morbid obesity, mechanical ventilation, emphysema, or chest wall deformity.
- Prosthetic valves are in place.
In patients with high clinical suspicion for IE, a normal echocardiographic result is not sufficient to discontinue diagnostic assessment or treatment. TTE or TEE should be repeated within 7 to 10 days. TTE or TEE can be used subsequently to assess the response to treatment or progression of the disease. Please see Figure 62.10 for the echocardiography algorithm.\(^{6,12}\)

### Radiography

Chest radiographs are obtained routinely in most patients with cardiopulmonary symptoms, fever, or both. No specific finding on the chest radiograph is pathognomonic for IE. Multiple bilateral pulmonary infiltrates might be a clue that septic emboli may be present (Fig. 62.11, A).

CT is an excellent tool for the evaluation of symptoms that may be associated with IE. The discovery of ischemic or infectious foci or abscesses, especially multiple lesions, should raise suspicion for a septic focus, such as IE. Contrast-enhanced CT is preferred for differentiating mass lesions with necrotic centers from abscesses.

Chest CT may better identify multiple septic emboli, effusions, or pulmonary abscesses (see Fig. 62.11, B). Brain CT for the evaluation of patients with neurologic or neuropsychiatric symptoms may demonstrate ischemic or infectious foci. Contrast-enhanced abdominopelvic CT might identify ischemia or infarction of the intestines, liver, spleen, or kidneys (Fig. 62.12).

For identifying the presence of mycotic aneurysms or peripheral embolization, conventional angiography remains the “gold standard,” although screening may be undertaken with CT angiography or magnetic resonance angiography.

### Lumbar Puncture

Lumbar puncture is not helpful in making the diagnosis of IE but is mandatory for diagnosing meningitis. Headache, neck stiffness, fever, alteration in mental status, or any combination of these symptoms should make one think of the diagnosis of meningitis. Independent of IE or a complication of IE, the diagnosis of meningitis—especially bacterial meningitis—must be made expeditiously. Lumbar puncture allows the EP to make the diagnosis of meningitis, initiate treatment, and ultimately, identify the causative organism.

### Treatment

#### Resuscitation

Emergency treatment always begins with the cardinal ABCs of resuscitation—airway, breathing, and circulation. Patients with issues in any of these areas must be stabilized by the
SECTION VI  CARDIAC DISORDERS

Fig. 62.11  Septic emboli. A, A chest radiograph shows two nodular densities (arrows). In this case they are foci of infection from embolization of infected vegetations. B, This non–contrast-enhanced computed tomography scan of the chest demonstrates multiple small infiltrates (arrows) caused by septic embolization.

Fig. 62.12  Renal infarction. A contrast-enhanced abdominopelvic computed tomography scan demonstrates patchy uptake of intravenous contrast agent by the right kidney. Gray areas (white arrow) within the anterolateral aspect of the midpole of the right kidney represent infarction caused by septic emboli from infective endocarditis. This contrasts with the rather homogeneously white, well-perfused left kidney and posterior aspect of the right kidney (black arrows). (Courtesy Jeffrey Newhouse, MD.)

usual methods. Supplemental oxygen or endotracheal intubation (or both) should be used as needed. Circulatory instability as a result of either cardiogenic or septic shock should be corrected with volume or pressor support, or both. Refractory cardiogenic shock may require the use of an intraaortic balloon counterpulsation device (contraindicated in patients with aortic insufficiency) or emergency heart surgery.

EMPIRIC ANTIBIOTIC THERAPY
Antibiotics are the keystone of treatment of IE, and selection of the proper regimen depends on the causative organism. Identification of the specific organism and its resistance pattern allows a properly tailored antibiotic regimen that minimizes the overuse of extended-spectrum agents. With this in mind, EPs should make every effort to obtain serial blood specimens for culture before starting antibiotic treatment. Three sets (aerobic and anaerobic) of blood culture specimens should be obtained. The sets should ideally be collected at least 30 minutes apart and over a period of 3 to 6 hours.

The urgency for empiric antibiotic therapy varies by patient subgroup. In stable patients with subacute manifestations and native valves who have signs and symptoms most consistent with a viral syndrome, antibiotic therapy can be withheld for hours and even days to allow proper culture results to be obtained. Patients with the same stable, subacute findings and viral syndrome–type symptoms but with a prosthetic valve or a history of injection drug use should be admitted to the hospital and receive appropriate empiric antibiotic therapy after the 3- to 6-hour collection of serial blood culture specimens. In a patient with a concomitant infectious process such as meningitis, pneumonia, or abscess and in whom the diagnosis of IE is being entertained, the serial blood culture specimens should still be collected but over a shorter time frame to allow sooner initiation of appropriate empiric antibiotic therapy to cover both the identified infection and the possible IE. Finally, in a patient with an acute, unstable manifestation of suspected IE, empiric antibiotics should not be withheld for collection of serial blood culture specimens. Three specimens can be collected over a 5- to 20-minute period to allow expeditious antibiotic treatment.

Unfortunately for the EP, the causative organism is rarely known because culture results are often not available yet. As with many infections, the EP must choose an empiric regimen. So how does the EP choose the empiric regimen? A group of organisms are known to cause IE (see Box 62.1). Certain of these organisms are more common, depending on the clinical scenario (see Table 62.2). Armed with this knowledge, the EP can tailor the empiric antibiotic regimen to the clinical scenario presented. Examples of such scenarios are native valve involvement, prosthetic valve involvement, injection drug use, history of allergy to antibiotics, prolonged hospitalization, admission to the intensive care unit, and a high prevalence of resistant organisms (Box 62.5). All these factors would influence the antibiotic regimen chosen.

Should the empiric regimen include antibiotics that cover all possible organisms and all resistance patterns? Actually, because many patients with IE have stable, subacute manifestations, the EP is not forced to achieve a perfect match of
Endocarditis

**BOX 62.5 Clinical Scenarios to Help Tailor an Empiric Antibiotic Regimen for a Patient with Suspected Infective Endocarditis**

Important factors in choosing an antibiotic are as follows:
- Acuity of findings
- Native valve endocarditis
- Prosthetic valve endocarditis
- Endocarditis in an injection drug user
- Recent or current use of antibiotics
- Recent hospitalization
- Antibiotic allergies
- Renal function
- Relapse of previously treated endocarditis
- Regional prevalence of certain organisms and resistance patterns

Organism and antibiotic. Changes can be made in 2 to 3 days, when the organisms and resistance patterns become known. In contrast, for unstable, acute cases, EPs should maximize coverage to ensure that they account for all possibilities of organism and resistance. Morbidity and mortality could be influenced by failure to properly treat early.

Initial antibiotic therapy should always be parenteral and bactericidal. Because of growing antibiotic resistance, combination therapy with two or more agents should be used. Recommended empiric antibiotic regimens are listed in Table 62.4.

For complex cases, it is advisable to seek the expertise of an infectious disease specialist. In addition, patients with confirmed IE require prolonged antibiotic administration and will probably be discharged with a long-term central intravenous catheter such as a Groshong catheter or peripherally inserted central catheter.

**Table 62.4 Empiric Antibiotic Regimen for Presumed Infectious Endocarditis**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Regimen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected native valve IE with a subacute manifestation</td>
<td>Penicillin G, 200-400 U/kg (normal adult dose, 12-20 million U/day) IV divided q4h, or ampicillin, 200 mg/kg/day (normal adult dose, 12 g/day) IV divided q4h plus Nafcillin or oxacillin, 200 mg/kg/day (normal adult dose, 12 g/day) IV divided q4h plus Gentamicin, 1 mg/kg IV or IM q8h (adjust for peak serum concentration of 3-4 mcg/mL and trough of &lt;1 mcg/mL)</td>
</tr>
<tr>
<td>Suspected native valve IE with the following characteristics: Patient with penicillin allergy or Acute manifestation or History of injection drug use or From a region with a high incidence of IE caused by <em>Staphylococcus aureus</em>, especially oxacillin-resistant <em>S. aureus</em></td>
<td>Vancomycin, 15 mg/kg IV q12h (adjust for 1-hr peak serum concentration of 30-45 mcg/mL and trough of 10-15 mcg/mL) plus Gentamicin, 1 mg/kg IV or IM q8h (adjust for peak serum concentration of 3-4 mcg/mL and trough of &lt;1 mcg/mL)</td>
</tr>
<tr>
<td>Suspected prosthetic valve IE</td>
<td>Vancomycin, 15 mg/kg IV q12h (adjust for 1-hr peak serum concentration of 30-45 mcg/mL and trough of 10-15 mcg/mL) plus Gentamicin, 1 mg/kg IV or IM q8h (adjust for peak serum concentration of 3-4 mcg/mL and trough of &lt;1 mcg/mL) plus Rifampin, 20 mg/kg/day (normal adult dose, 900 mg/day) PO divided q8h</td>
</tr>
</tbody>
</table>


*Empiric therapy must be designed on the basis of clinical and epidemiologic clues.
†The duration of therapy varies with the microorganism and its drug sensitivities, the presence of prosthetic devices, and the response to therapy.
‡The pediatric dose should not exceed the normal adult dose.
§Penicillin G or ampicillin is added to this regimen because nafcillin/oxacillin and gentamicin may not be adequate coverage of enterococci.
¶Aminoglycosides such as gentamicin should not be given as single daily doses.
∥Doses of vancomycin and gentamicin should be adjusted for reduced renal function, as well as measured serum concentration values.
**Rifampin increases the warfarin requirement for anticoagulation.

IE, Infectious endocarditis; IM, intramuscularly; IV, intravascularly; PO, orally.
CARDIAC PACING

Any hemodynamically unstable patient with a complete heart block, irrespective of cause, warrants at least temporary cardiac pacing. In the setting of IE, in which a high-degree heart block is unlikely to be a temporary condition, a transvenous pacemaker is preferable to transthoracic pacing.

ANTICOAGULATION

Anticoagulation is not indicated for patients with endocarditis. It prevents neither the formation nor the embolization of vegetations. In the setting of native valve IE, anticoagulation should be avoided because it affords no benefit and might cause harm by converting CNS infarcts from bland to hemorrhagic.

Understanding the risks associated with anticoagulation in the setting of IE, what does the EP do with patients who would normally require anticoagulation? An excellent example would be a patient with IE and an anticoagulation-requiring prosthetic valve. The recommendation is that anticoagulation should be continued, barring the presence of acute hemorrhage, CNS infarction or hemorrhage, or a mycotic aneurysm. Any complaint that may result from these issues should be fully investigated to best inform decisions regarding anticoagulation. CT of the brain should be performed in any patient with possible CNS involvement. Any patient with unexplained abdominal or flank pain should undergo contrast-enhanced abdominal CT to evaluate for the presence of a mycotic aneurysm. Visual complaints warrant a complete funduscopic examination. If contraindications are identified, temporary discontinuation of anticoagulation is appropriate even in patients with a prosthetic valve. In these circumstances, close consultation with the appropriate specialty services is recommended.

Patients taking warfarin should be switched to intravenous, unfractionated heparin in the event that cardiac surgery is required.

Aspirin has not been shown to prevent embolic events but is probably associated with an increased risk for bleeding. It therefore has no role in early management of IE.

SURGICAL THERAPY

There are both early and late indications for surgical intervention in the management of IE. Keeping this fact in mind, the EP should obtain early cardiothoracic surgery consultation if any early indications for surgery exist. The only true indication for early, emergency surgical intervention is severe CHF or cardiogenic shock secondary to valvular insufficiency. Intraaortic balloon counterpulsation devices can be used to temporize all forms of cardiogenic shock except that caused by aortic valve insufficiency. In the case of aortic valve incompetence, valve replacement becomes imperative. The presence of an annular or aortic abscess (with or without a conduction system disturbance), a sinus or aortic true or false aneurysm, or paravalvular leak of a prosthetic valve warrants surgical intervention but need not be performed as an emergency procedure if the patient is otherwise stable.

Other potential indications for surgery in patients with IE are failure of antibiotic therapy, vegetations larger than 10 mm on echocardiography, fungal endocarditis, early prosthetic valve endocarditis (within the first 2 months after surgery), and recurrent embolization despite medical therapy.

REMOVAL OF MEDICAL HARDWARE

Blood culture specimens should be obtained via any long-term indwelling intravascular catheter. These devices should then be removed. Decisions to remove prosthetic valves or pacemaker wires are complex and should be made in consultation with cardiology, cardiothoracic surgery, or infectious disease specialists (or all three).

FOLLOW-UP, NEXT STEPS IN CARE, AND PATIENT EDUCATION

All patients with suspected or confirmed IE should be admitted to the hospital. The EP might consider discharge from the ED if the following conditions are all met: low risk for IE (native valves, immunocompetent, no injection drug use, no comorbid conditions), a stable or subacute manifestation, non-diagnostic findings on TTE, and very well-defined follow-up. Such patients may undergo TEE as an outpatient, and the serial blood culture results can be followed by their personal physicians.

Otherwise, the disposition of all other patients with potential or confirmed IE is driven by the following factors:

- Need for further evaluation (diagnosis or extent of involvement not certain)
- Severity of the illness
- Need for surgical or mechanical support (e.g., mechanical ventilation, intraaortic balloon counterpulsation device)
- Need for intravenous antibiotic therapy
- Reliability of the patient
- Availability of close follow-up

Immediate operative care should be strongly considered if the surgical criteria are met. Patients in critical condition who do not require surgery should be admitted to the intensive care unit. Most other patients with presumed IE can be admitted to a medical service with cardiac monitoring for further evaluation, initiation of intravenous antibiotic therapy, and arrangement for further outpatient care.

NONBACTERIAL THROMBOTIC ENDOCARDITIS

Endocarditis is not always associated with infection. In some disease states, vegetations composed of bland, platelet-fibrin aggregates may adhere to the endocardium. Eventually, fibrosis of these lesions occurs. These vegetations are usually sterile but may become seeded with infectious organisms. Illnesses associated with nonbacterial thrombotic endocarditis (NBTE) include malignancies, severe burns, hypercoagulable states (e.g., antiphospholipid syndrome and disseminated intravascular coagulopathy), uremia, and connective tissue diseases such as systemic lupus erythematosus.

It stands to reason that the clinical manifestations of NBTE are related mainly to embolic phenomena and, occasionally, to valvular dysfunction. Without infectious vegetations, the generalized immune response and the localized destruction and infectious seeding of other organs do not occur. The primary indication for surgical intervention in patients with NBTE is valvular dysfunction, although surgery may be performed to prevent embolic events.
For more than 50 years, the American Heart Association (AHA) has set forth recommendations in an effort to prevent IE. Antimicrobial regimens were recommended for planned, potentially contaminated procedures (dental, respiratory, GI, and genitourinary) in an effort to prevent IE in at-risk populations. Unfortunately, these guidelines lacked good evidence to support their efficacy and were so complex that their implementation was difficult. In April 2007, the AHA released new guidelines in an effort to address these issues.

Rather than provide prophylaxis to patients at risk for the development of IE, the 2007 guidelines have changed to recommend that antimicrobial prophylaxis be administered only to patients at highest risk for an adverse outcome from IE (Box 62.6), thereby greatly reducing the group of eligible patients. The procedures for which prophylaxis is recommended are listed in Box 62.7 and antimicrobial regimens in Table 62.5.

EPs may encounter difficulty managing the expectations of patients who were previously recommended to receive IE prophylaxis but now are not. The rationale for the changes is the lack of scientific evidence to support the claim that IE prophylaxis is actually effective. In fact, the bacteremia resulting from daily activities such as toothbrushing and eating is more likely to result in IE than is the bacteremia associated with dental procedures. Therefore, even if 100% effective, prophylaxis probably prevents only an extremely small number of cases of IE. The cost of prophylaxis is borne financially and through adverse drug reactions. As a result, the AHA is now emphasizing maintenance of optimal oral health and the lack of scientific evidence to support the claim that IE prophylaxis is actually effective. In fact, the bacteremia resulting from daily activities such as toothbrushing and eating is more likely to result in IE than is the bacteremia associated with dental procedures. Therefore, even if 100% effective, prophylaxis probably prevents only an extremely small number of cases of IE. The cost of prophylaxis is borne financially and through adverse drug reactions. As a result, the AHA is now emphasizing maintenance of optimal oral health and

**ENDOCARDITIS PROPHYLAXIS**

Cardiac conditions associated with the highest risk for an adverse outcome from endocarditis for which antibiotic prophylaxis is recommended are as follows:

- Prosthetic cardiac valves
- Previous infective endocarditis
- Congenital heart disease (CHD)*
  - Unrepaired cyanotic CHD, including palliative shunts and conduits
  - Completely repaired congenital heart defect with prothetic material or device, whether placed by surgery or by catheter intervention, during the first 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 (which inhibits endothelialization)
  - Cardiac valvulopathy in a cardiac transplantation recipient


*Except for the conditions listed here, antibiotic prophylaxis is no longer recommended for any other form of CHD.
†Prophylaxis is recommended because endothelialization of prosthetic material occurs within 6 months after the procedure.

**BOX 62.7 Emergency Department Procedures Requiring Antimicrobial Prophylaxis Against Infective Endocarditis in High-Risk Patients**

Patients at high risk for an adverse outcome from infective endocarditis (see Box 62.6) should receive antimicrobial prophylaxis (see Table 62.4) for the following procedures:

**Dental Procedures**
- All dental procedures that involve manipulating gingival tissue or the periapical region of teeth or perforating the oral mucosa.

The following procedures and events do not need prophylaxis: routine anesthetic injections through noninfected tissue, taking of dental radiographs, placement of removable prosthodontic or orthodontic appliances, placement of orthodontic brackets, shedding of deciduous teeth, and bleeding from trauma to the lips or oral mucosa.

**Otorhinolaryngologic/Respiratory Procedures**
- Any surgical procedure that involves an incision in respiratory mucosa (e.g., peritonsillar abscess incision and drainage, cricothyroidotomy, tracheotomy, tonsillectomy and/or adenoidectomy)
- Bronchoscopy with a procedure that involves an incision in respiratory mucosa

**Minor Surgical Procedures**
- Any surgical procedure that involves infected skin, skin structure, or musculoskeletal tissue (e.g., incision and drainage of an abscess)

NOTE: Prophylaxis for gastrointestinal procedures is no longer recommended.

NOTE: Prophylaxis for genitourinary procedures is recommended only if the patient is known to have enterooccal colonization or urinary tract infection at the time of instrumentation.

hygiene as the means to reduce the incidence of IE related to daily activities, as well as dental procedures.\textsuperscript{17}

**ACKNOWLEDGMENT**

We are indebted to Dr. Ahmet R. Sayan (cardiology) for his critical appraisal of this manuscript.

**SUGGESTED READINGS**


**REFERENCES**

References can be found on Expert Consult @ www.expertconsult.com.
REFERENCES