In contrast to anaerobic osteomyelitis, most cases of anaerobic arthritis (Chap. 157) involve a single isolate, and most cases are secondary to hematogenous spread. The most common isolates are *Fusobacterium* species. Most of the patients involved have uncontrolled peritonsillar infections progressing to septic cervical venous thrombophlebitis (Lemierre's syndrome) and resulting in hematogenous dissemination with a predilection for the joints. Unlike anaerobic osteomyelitis, anaerobic pyoarthritis in most cases is not polymicrobial and may be acquired hematogenously. Anaerobes are important pathogens in infections involving prosthetic joints; in these infections, the causative organisms (such as *Peptostreptococcus* species and *P. acnes*) are part of the normal skin microbiota.

Bacteremia Transient bacteremia is a well-known event in healthy individuals whose anatomic mucosal barriers have been injured (e.g., during dental extractions or dental scaling). These bacteremic episodes, which are often due to anaerobes, have no pathologic consequences. However, anaerobic bacteria are found in cultures of blood from clinically ill patients when proper culture techniques are used. Anaerobes have accounted for 5% (range at various institutions, 0.5–12%) of cases of clinically significant bacteremia. The incidence of anaerobic bacteremia decreased from the 1970s through the early 1990s. This change may have been related to the administration of antibiotic prophylaxis before intestinal surgery, the earlier recognition of localized infections, and the empirical use of broad-spectrum antibiotics for presumed infection. Recent reports present conflicting data regarding rates of anaerobic bacteremia. A study from the Mayo Clinic compared three periods (1993–1996, 1997–2000, and 2001–2004) and found a 74% increase in the mean incidence of anaerobic bacteremia; this finding contrasts with a 45% decrease in incidence from 1977 to 1988 at the same institution. In contrast, a report from Switzerland compared two periods (1997–2001 and 2002–2006) and found decreases in both the number of anaerobe-positive blood cultures and the proportion of all blood culture isolates that were anaerobes.

The majority of anaerobic bacteremias are due to gram-negative bacilli—mainly the *B. fragilis group*, with *B. fragilis* most commonly isolated (60–80% of cases). Other organisms causing bacteremia include *Clostridium* species (10%), *Peptostreptococcus* species (10%), and *Fusobacterium* species (5%).

Once the organism in the blood has been identified, both the portal of bloodstream entry and the underlying problem that probably led to seeding of the bloodstream can often be deduced from an understanding of the organism's normal site of residence. For example, mixed anaerobic bacteremia including *B. fragilis* usually implies a colonic pathology with mucosal disruption from neoplasia, diverticulitis, or some other inflammatory lesion. Debilitating diseases such as malignancies, diabetes, organ transplantation, and abdominal and pelvic surgeries are among the predisposing factors for anaerobic bacteremia. In a retrospective nested case–control study, diabetes was identified as a risk factor for anaerobic bacteremia when the source of bacteremia was unknown. The initial manifestations are determined by the portal of entry and reflect the localized condition. When bloodstream invasion occurs, patients can become extremely ill, with rigors and hectic fevers. The clinical picture may be quite similar to that seen in sepsis involving aerobic gram-negative bacilli. Although complications of anaerobic bacteremia (e.g., septic thrombophlebitis and septic shock) have been reported, their incidence in association with anaerobic bacteremia is low. Anaerobic bacteremia is potentially fatal and requires rapid diagnosis and appropriate therapy. Reported case–fatality rates are high, ranging from 25% to 44%, and appear to increase with the age of the patient (with reported rates of >66% among patients >60 years old), with the isolation of multiple species from the bloodstream, and with the failure to surgically remove a focus of infection. The attributable mortality rate for bacteremia associated with the *B. fragilis* group was examined in a matched case–control study. Patients with *B. fragilis*–group bacteremia had a significantly higher mortality rate (28% vs 8%), with an attributable mortality rate of 19.3% and a mortality risk ratio of 3.2.

Endocarditis and Pericarditis (See also Chap. 155) Endocarditis due to anaerobes is uncommon. However, anaerobic streptococci, which are often classified incorrectly, are responsible for this disease more frequently than is generally appreciated. Gram-negative anaerobes are unusual causes of endocarditis. Signs and symptoms of anaerobic endocarditis are similar to those of endocarditis due to facultative organisms. Mortality rates of 21–43% have been reported for anaerobic endocarditis.

Anaerobes, particularly *B. fragilis* and *Peptostreptococcus* species, are uncommonly found in infected pericardial fluids. Anaerobic pericarditis is associated with a mortality rate of >50%. Anaerobes can reach the pericardial space by hematogenous spread, by spread from a contiguous site of infection (e.g., heart or esophagus), or by direct inoculation arising from trauma or surgery.

DIAGNOSIS

There are three critical steps in the diagnosis of anaerobic infection: (1) proper collection of specimens; (2) rapid transport of the specimens to the microbiology laboratory, preferably in anaerobic transport media; and (3) proper handling of the specimens by the laboratory. Specimens must be collected by meticulous sampling of infected sites, with avoidance of contamination by the normal microbiota. When such contamination is likely, the specimen is unacceptable. Examples of specimens unacceptable for anaerobic culture include sputum collected by expectoration or nasal tracheal suction, bronchoscopy specimens, samples collected directly through the vaginal vault, urine collected by voiding, and feces. Specimens appropriate for anaerobic culture include sterile body fluids such as blood, pleural fluid, peritoneal fluid, cerebrospinal fluid, and aspirates or biopsy samples from normally sterile sites. As a general rule, liquid or tissue specimens are preferred; swab specimens should be avoided.

Because even brief exposure to oxygen may kill some anaerobic organisms and result in failure to isolate them in the laboratory, air must be expelled from the syringe used to aspirate the abscess cavity, and the needle must be capped with a sterile rubber stopper. It is also important to remember that prior antibiotic therapy reduces the cultivability of these bacteria. Specimens can be injected into transport bottles containing a reduced medium or taken immediately in syringes to the laboratory for direct culture on anaerobic media. Delays in transport may lead to a failure to isolate anaerobes due to exposure to oxygen or overgrowth of facultative organisms, which may eliminate or obscure any anaerobes that are present. All clinical specimens from suspected anaerobic infections should be subjected to Gram's staining and examined for organisms with characteristic morphology. It is not unusual for organisms to be observed on Gram's staining but not isolated in culture.

Because of the time and difficulty involved in the isolation of anaerobic bacteria, diagnosis of anaerobic infections must frequently be based on presumptive evidence. There are few clinical clues to the probable presence of anaerobic bacteria at infected sites. The involvement of certain sites with lowered oxidation-reduction potential (e.g., avascular necrotic tissues) and the presence of an abscess favor the diagnosis of an anaerobic infection. When infections occur in proximity to mucosal surfaces normally harboring an anaerobic microbiota, such as the gastrointestinal tract, female genital tract, or oropharynx, anaerobes should be considered as potential etiologic agents. A foul odor is often indicative of anaerobes, which produce certain organic acids as they proliferate in necrotic tissue. Although these odors are nearly pathognomonic for anaerobic infection, the absence of odor does not exclude an anaerobic etiology. The presence of gas in tissues is highly suggestive, but not diagnostic, of anaerobic infection. Because anaerobes often coexist with other bacteria and cause mixed or synergistic infection, Gram's staining of exudate frequently reveals multiple morphotypes suggestive of anaerobes. Sometimes these organisms have morphologic characteristics associated with specific species.

When cultures of obviously infected sites or purulent material yield no growth, streptococci only, or a single aerobic species (such as *E. coli*) and Gram's staining reveals a mixed flora, the involvement of anaerobes should be suspected; the implication is that the anaerobic microorganisms have failed to grow because of inadequate transport and/or culture techniques. Failure of an infection to respond to antibiotics that are not active against anaerobes (e.g., aminoglycosides and—in