Automated Blood Cultures

XIANG Y. HAN

Introduction

A clinically suspected infection is ultimately confirmed by isolation or detection of the infectious agent. Subsequent identification of the microorganism and antibiotic susceptibility tests further guide effective antimicrobial therapy. Bloodstream infection is the most severe form of infection and is frequently life-threatening, and blood culture to detect circulating microorganisms has been the diagnostic standard. Much of the scientific and technologic advances in blood culture were made from the 1970s to the 1990s; this chapter briefly reviews various aspects of blood culture with emphasis on automated culturing systems.

Principles

The principles and scientific basis to optimize the diagnostic yield of blood cultures have been reviewed and summarized (Weinstein, 1996; Reimer, 1997). Most parameters were initially established for manual blood culture systems that used basal culture media. A recent study addressed some of these parameters for newer culture systems and media and found them to be mostly valid nowadays (Cockerill et al., 2004). Major features are summarized below.

Host and Microbial Factors

Invasion of the bloodstream by microorganisms reflects the failure of initial host defense, such as the loss of integrity of skin and mucosa and weakening of the innate and acquired immunity. Among those patients bearing an intravascular device or using recreational drugs intravenously, direct blood seeding of a microorganism is also possible. Once in the bloodstream, microbes are constantly attacked by host defenses, such as complements, phagocytic leukocytes, and antibodies. The ability of invading microorganisms to evade or shield off host defense or antimicrobials favors their survival and dissemination in the bloodstream. Therefore, both the host
and microbial factors determine the occurrence, severity, and duration of septic episodes and the yield of culture recovery. The presence of antimicrobial agents in the circulation may also reduce culture recovery.

**Timing, Volume, and Frequency of Cultures**

Blood culture should be drawn, if at all possible, before initiation of empirical antibiotic therapy. Conversely, persistence of fever during therapy is also a common reason to repeat culture. Timing the blood-draw has bearings on culture recovery. Most bacteremia or fungemia are not constant except in the case of endocarditis; thus, the host responses, such as rising fever, likely herald the best time to draw blood culture. The preferred volume is 20–30 mL; lower volume reduces culture sensitivity, whereas higher volume does not necessarily increase sensitivity, because of more host factors and/or antimicrobials introduced, while adding to the cost and iatrogenic anemia. Generally, for an adult patient, 10 mL of blood should be drawn to each culture bottle (a set of aerobic and anaerobic bottles) to reach a blood/broth ratio of 1:5 to 1:10. For each septic episode, two to three sets of cultures over a 24-h period provide maximum recovery for the offending microorganisms. How frequent to draw blood for follow-up culture is more of a clinical decision depending on the patient’s response to initial treatment and host and microbial factors; it may take 2–3 days or even longer for a patient to show improvement.

**Atmosphere and Length of Incubation**

Traditionally, two aerobic bottles and two anaerobic bottles have been recommended. However, the declining proportion of bacteremias due to obligate anaerobes has led to the suggestion that routine anaerobic cultures are not needed and can be tailored to the needs of an individual institution and patient population. How long to incubate? Several studies on different culturing systems have shown that 5-day culturing and testing is sufficient to recover nearly all significant microorganisms (~99%) (Doern et al., 1997; Wilson, 1997; Han and Truant, 1999; Cockerill et al., 2004). Most fastidious organisms can also be recovered in 5 days, such as the HACEK organisms (*Haemophilus aphrophilus*, *Actinobacillus actinomycetemcomitans*, *Cardiobacterium hominis*, *Eikenella corrodens*, and *Kingella kingae*), *Brucella* spp., and nutritionally variant streptococci (Doern et al., 1996). A new species, *Cardiobacterium valvarum*, proposed by us as well as a cause of endocarditis, was cultured within 3 days (Han et al., 2004b). The length of culture for *Brucella* spp. had been controversial until the study by Bannatyne et al. (1997), which showed that 90 of 97 such bacteremic patients became culture-positive within 5 days. Blood cultures for *Francisella tularensis*—fewer than a dozen such culture-positive cases in the United States currently—mostly become positive after incubation for 3 to 8 days (reviewed by Doern et al., 1996; Han et al., 2004a).