

Controlling blood-culture contamination rates

By Dennis J. Ernst, MT(ASCP)

One of the more frustrating problems plaguing hospitals and laboratories is the rate with which bacteria external to the patient contaminate blood cultures. If specimen collectors use poor collection technique, they can introduce organisms into blood-culture bottles that mislead lab technicians and physicians into thinking that patients have potentially life-threatening bacteremias when, in fact, they do not. The results of such misleading findings can be measured in both financial and human terms. One study shows that contaminated blood cultures can increase a patient's hospital stay by as much as 4.5 days and add more than \$5,000 to the cost of treatment (adjusted for inflation since the study was published).^{1,2} More importantly, contaminated blood cultures can keep patients from rejoining their families and their jobs and from reclaiming their daily lives.

Because physicians rely heavily on blood-culture results to diagnose and monitor febrile patients, few results can have such a profound effect on patient care as an erroneous blood-culture report. Since the advent of cross-training for healthcare professionals, it has never been more difficult to control blood-culture contamination rates. Because healthcare workers from many different disciplines within a facility are now drawing blood specimens — and the lines of authority over them are often blurred — many laboratorians are understandably frustrated and tempted to give up the fight to maintain unadulterated samples. Recent studies have given laboratorians new ways to combat the problem. A review of these findings, as well as information about sound collection practices, can arm healthcare professionals with specific strategies to prevent the expensive and unfortunate consequences of poor phlebotomy technique.

Bacteria can infect the circulatory system from intravascular and extravascular sources. Intravascularly, microorganisms can originate from infected organs, cavities, fluids (e.g., cerebral spinal, synovial, or pericardial), untreated superficial wounds, abscesses, urinary tract infections, or respiratory infections. Such infections, if aggressive or left untreated, can spread rapidly throughout the body. Immunocompromised patients are especially vulnerable to isolated infections becoming systemic. Extravascular sources of septicemia-contaminated vascular-access devices (e.g., arterial lines or central venous catheters), urinary catheters, or other foreign devices can also provide ports for bacteria to exploit the oxygen- and nutrient-rich environment of the circulatory system. Regardless of the source of the infection, if an isolated infection becomes systemic, physicians must act quickly.

Reporting positive blood cultures that are not consistent with the patient's condition, diagnosis, or clinical symptoms, however, puts physicians in a quandary. Often, doctors must decide whether to ignore a result that could be life threatening, or to consume valuable hospital resources fighting an infection that might not exist. Posed with this paradox, many choose the conservative approach: administer antibiotics, extend the patient's stay, and monitor the patient with more tests. Few collection errors are as costly to the hospital, the laboratory, and the patient as blood cultures that are compromised by inattentive specimen-collection practices.

According to the standards published by the American Society for Microbiology, the rate of blood-culture contamination should not exceed 3%, but eliminating all suspected false positives is not a realistic goal.³ Some suspected contaminants might be associated with transient bacteremias (bacteria that exist

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LEARNING OBJECTIVES

Upon completion of this article the reader will be able to:

1. Describe three indicators of a contaminated blood culture
2. Identify four common causes of contaminated blood cultures
3. Discuss four ways to reduce contamination rates.
4. Describe the proper site preparation procedure for blood collection

momentarily in the bloodstream and then are engulfed by the body's cellular immune response). These bacteremias enter the bloodstream through stress or trauma to mucous membranes (e.g., dental work, injuries to the nasopharyngeal cavities, or obstructed bowel), or through invasive procedures that disrupt tissue integrity (e.g., urinary catheterization or colonoscopy). The average contribution of transient bacteremias to a facility's contaminated-culture rate can never be known. When a hospital finds its overall rate creeping beyond 3%, however, it is an indication that blood cultures are not being collected with proper attention to aseptic technique. For a listing of the rates at which different organisms contaminate blood-culture samples, see Table 1.

Table 1. Percentage of organisms that exist as contaminants vs. true positives

Organism	False positives	True positives
<i>Bacillus</i> spp.	>90%	<10%
Coag-negative <i>Staphylococcus</i> spp.	>90%	<10%
<i>Propionibacterium</i> spp.	>90%	<10%
<i>Corynebacterium</i> spp.	80%	20%
Viridans streptococci	50%	50%
<i>Clostridium</i> spp.	40%	60%
<i>Staphylococcus aureus</i> spp.	25%	75%
<i>Enterococcus</i> spp.	15%	85%

Source: From a presentation by Dr. Patrick Murray, University of Maryland School of Medicine, Microbiology for the Millennium Conference, Feb. 17-19, 1999, Baltimore, MD.

Indicators of contamination

Fortunately, indicators exist that can alert physicians and laboratorians that the specimen might have been contaminated during collection or processing. These indicators include:

- frequency of positive bottles among collections;
- Gram-stain results from positive bottles;
- white blood cell (WBC) count/differential;
- number of organisms isolated;
- patient symptoms; and
- time required for growth to become detectable.⁴

Frequency. Blood cultures that are legitimately positive, (that is, contain growth from *in vivo* bacteria), typically demonstrate growth in every set collected. For example, if three sets of cultures are collected and all three sets demonstrate growth, it is probable that the patient has a rampant bacterial infection. Conversely, growth in only one out of three cultures suggests contamination.

Gram-stain results. Gram stains from positive cultures that demonstrate characteristics of normal skin flora should be suspect. Gram-positive cocci in clusters indicate staphylococci; small Gram-positive rods appearing in palisades ("picket fence" arrangements) suggest *Corynebacterium* spp.; Gram-positive, club-shaped rods characterize *Propionibacterium* spp.; and Gram-positive cocci in pairs are typical of alpha and gamma streptococci. The large Gram-positive rods of *Bacillus* spp., although not normal skin flora, are an environmental contaminant that can find their way onto the skin and ultimately into a blood-culture bottle. The presence of any of these organisms hints that the puncture site might not have been cleansed with attention to antiseptic technique. Unfortunately, some of these organisms can also cause septicemia; so in the absence of other indicators, the identification of these organisms by Gram-stain morphol-

ogy alone is not reason enough to dismiss the culture as contaminated.

Elevated WBC count/abnormal differential. Legitimately positive blood cultures are often accompanied by an elevated white blood cell count and provide evidence that a cellular response to an infection is taking place. Additionally, a left shift in the differential (>10% bands), with or without an elevated WBC, adds credibility to a positive blood culture. The absence of these indicators is a vote against a legitimately positive culture.

Multiple organisms isolated. True septicemias are almost exclusively caused by an infection with a singular organism. Although multiple-organism infections can occur, the presence of two or more organisms, especially in combination with other indicators, is usually a result of poor site preparation.

Patient symptoms. The body's natural response to bacterial invasions is to trigger a rise in temperature to burn out the pathogen. This defense might present itself in the form of "fever spikes," in which the patient experiences a rising and falling of temperature, or as constant, low-grade fevers. Legitimately septic patients, therefore, are constantly or occasionally febrile. The absence of a temperature in the presence of positive blood cultures creates a conflicting picture and raises questions about the validity of the culture result.

Time required for growth to become detectable. Patients who are legitimately septic often demonstrate immediate growth in their blood-culture bottles. Assuming sufficient volumes of blood have been inoculated into the bottles, bacteria should multiply to detectable levels within 48 hours, often much sooner. Conversely, growth that is slow to emerge indicates that only a miniscule number of organisms have been inoculated into the broth, which is typical for collections contaminated from external sources.

Questionable culture results should be interpreted in light of all these factors before treating the patient for septicemia. If these indicators exist in combination, contamination is suggested. To simplify the decision-making process, many facilities adopt an algorithm based on some combination of these indicators.

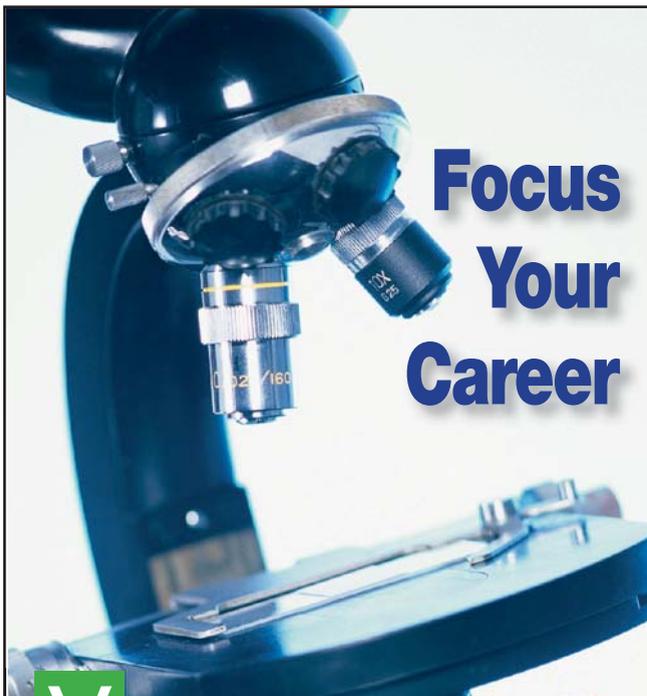
Factors affecting blood-culture collection

Certain factors have a critical bearing on drawing a blood-culture specimen. These factors include:

- training of blood-collection personnel;
- location of collection site;
- preparation of puncture site;
- blood-collection equipment; and
- collection volume.

Personnel. A Q-Probe study released by the College of American Pathologists (CAP) in 1998 identified several key elements that contribute to high contamination rates. One clearly determining factor was the use of a multiskilled workforce to draw blood specimens. When blood cultures were collected by personnel who were not members of a specifically designated phlebotomy team, the contamination rate was significantly higher (77%) than for members of such a team. In fact, the lowest contamination rates were associated with facilities in which 90% or more of the blood cultures were collected by a trained phlebotomy staff. A second study found

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Table 2. Contamination rates in percent of blood cultures drawn by phlebotomy team vs. nonphlebotomy team^{3,5}

	Facilities in which most cultures were drawn by a team of phlebotomists	Facilities in which most cultures were drawn by nonphlebotomists
Weinbaum, et al. (Unit A)	1.2%	8.4%
Wienbaum, et al. (Unit B)	1.0%	4.8%
Schifman, et al	2.2%	3.9%

a dramatic reduction in blood-culture contamination (as much as 86%) when a collection staff was established (see Table 2).

Several studies have projected the overall cost savings to a facility when a dedicated phlebotomy team is employed to collect blood cultures. An editorial published in the *Mayo Clinic Proceedings* in 1998 calculates that "the typical savings associated with using a phlebotomy service can be predicted to be about \$20 per blood-culture specimen collected."² A study by Weinbaum, et al, reports that the mean hospital charges for patients with false-positive blood cultures was more than 50% higher than for similar patients with true-negative cultures.³ The report projected that the 487-bed facility studied might save as much as \$1.2 million annually if it employed a dedicated phlebotomy team to collect blood cultures.

Unfortunately, many laboratories no longer have the luxury of maintaining a dedicated team of phlebotomists. For these facilities, it is critically important to continuously monitor and educate those collecting blood for cultures to keep contamination rates as low as possible. One approach is to employ a "micromanagement" strategy. A study published in the *Archives*

The lowest contamination rates were associated with facilities in which 90% or more of the blood cultures were collected by a trained phlebotomy staff.

of Pathology and Laboratory Medicine showed that almost a 50% reduction in contaminated blood cultures occurred when the contamination rates of each collector were monitored and individual collectors were informed of their rates.⁶

Site selection. The location of the collection site has a significant impact on the potential for a culture to be contaminated. Draws from vascular-access devices, such as arterial lines, central venous catheters, and heparin locks, have been shown to result in high contamination rates. Because these ports pass through the skin and remain there for long periods of time, they are susceptible to bacterial colonization. Colonized bacteria multiply and accumulate in and around invasive ports, and can be pulled into blood specimens drawn from those sites.

To confirm that a positive blood culture is caused by colonization, a second blood culture must be drawn at the same time by skin puncture, and the results compared. (Some facilities have a policy to draw peripheral cultures simultaneously whenever a culture is taken through a vascular-access device.) A negative culture by venipuncture, in conjunction with a positive culture by line draw, confirms colonization, whereas positive cultures drawn from both sites confirm septicemia. If the culture collected by venipuncture is contaminated because of poor technique, then it becomes necessary to compare the organisms isolated to determine if true septicemia exists. Hence, any benefits to collecting cultures by a

line draw are outweighed by the expense of confirmatory collections by venipuncture and should be avoided.

Site preparation. Aseptic site preparation is without question the single most important factor in collecting uncontaminated blood cultures. Iodine-based antiseptics, sometimes used along with isopropyl alcohol, have become the industry standard for preparing puncture sites. Separately packaged alcohol preps and antiseptic swabs are available, but using them in tandem has been found to be less effective than employing commercially prepared prep kits, such as Cepti-Seal, ChloroPrep (Mediflex Hospital Products, Overland Park, KS) and Persist (BD, Franklin Lakes, NJ).⁷

Not all iodine compounds are equal. One study showed that iodine tincture is more effective in reducing contamination rates than iodine in an iodophor (e.g., povidone).⁸ Additionally, it appears that the effectiveness of the antiseptic is a function of who is using it. The previously mentioned CAP Q-Probe study showed that preparation of puncture sites with tincture of iodine, as opposed to an iodophor, was superior in combating contamination at sites where nonphlebotomy personnel collected cultures. Both forms of iodine were effective in facilities that employed a designated phlebotomy team. The study's authors speculate that such teams are better trained and have a greater awareness of the relationship between contact time and site asepsis.

A relative newcomer to the arsenal of site preparation options is chlorhexidine scrubs. Studies show that chlorhexidine is just as effective as iodine, but with an extremely low potential for skin irritation and allergic contact sensitization.

Site preparation starts with a 30- to 60-second scrub with the antiseptic. (If isopropyl alcohol is used, it is applied first to remove most of the surface contaminants, followed by the application of the antiseptic.) When applying the antiseptic, cover the skin two inches or more in all directions, then complete the process by starting from the center and moving outward in circles of increasing diameter. Some procedures call for an antiseptic scrub followed by an alcohol cleansing, then a final application of the antiseptic in increasingly larger concentric circles, as described. Regardless, the bacteriostatic effect of antiseptic compounds is directly proportional to the length of time they are allowed to remain in contact with the skin. Generally, at least 30 seconds of contact is necessary before the puncture to assure proper site preparation.

Blood-culture contamination is most likely to occur during attempts to relocate difficult-to-find veins by palpation

after a site has been cleansed. This practice obviously reintroduces skin contaminants to the site and, potentially, into the bottle. There are techniques, which make re-palpation unnecessary. Before cleansing, making a mental note of a vein's location in relation to certain skin markers (such as pigmentation or creases) can reduce the urge to re-palpate. Collectors should resist the temptation to re-palpate an aseptically prepared puncture site, but if unsure of a vein's location, they can re-palpate above and below the intended puncture site while avoiding the exact point of entry. Cleansing the tip of the gloved index finger for palpation is not advised.

An additional factor identified in the CAP Q-Probe study that contributes to low contamination rates is the practice of decontaminating the top of the blood-culture bottle before use. Some facilities cleanse the tops with alcohol; others use an iodine solution, allowing it to dry and remain in contact with the stopper for 30 seconds before removing the iodine with a fresh alcohol prep. Facilities should follow the recommendations of the bottle's manufacturer.

Equipment. Depending on the type of blood-culture bottle in use, collectors will fill bottles either by using a winged infusion (butterfly) set and a vacuum tube adapter or by drawing blood directly into a syringe through a needle or butterfly set.

Using a butterfly/adaptor set (see "Tips on collection technique" on page 18). After the puncture, the adapter should be positioned over the neck of the culture bottle and pressed downward so the interior needle punctures the bottle stopper. (The butterfly set should never be used without the tube-holder adapter. When not concealed, the needle that punctures the stoppers poses a risk of accidental needlestick.) If both aerobic and anaerobic bottles are included in the set, the aerobic bottle should be inoculated first for two reasons:

(1) Empty butterfly tubing can have up to 1 cc of dead-space volume. If this volume of air is pulled into anaerobic bottles, it can be detrimental to some anaerobic organisms.

(2) Ninety-eight percent of septicemias are caused by aerobic or anaerobic organisms that can tolerate aerobic environments (facultative anaerobes). If blood flow is interrupted and cannot be resumed before the anaerobic bottle is filled, most of the causative organisms of septicemia will still be detected.

Using a syringe. When blood is collected into a syringe — either directly or through a butterfly set — the safety feature of the needle should be immediately activated upon removal from the vein, removed from the syringe, and carefully discarded into an approved sharps container. Attach a

Continues on page 18

Protecting the collector

Blood-culture collections present additional risks of exposure to potentially infectious blood. To prevent exposures, the following guidelines can keep that risk to a minimum.

- 1 Use only needles designed with safety features.
- 2 Always use a safety transfer device when filling blood-culture bottles from a syringe.
- 3 Always use a tube holder adapter when collecting blood through a winged blood-collection set.
- 4 Do not try to forcefully evacuate blood from a syringe into culture bottles (or any specimen tubes). This risks exposure to bloodborne pathogens if the force results in the specimen's splattering.
- 5 Make sure a sharps container is within reach at the point of use.
- 6 Conceal or dispose of all sharps immediately after activating the safety feature.

NCCLS' order of draw

After conferencing with industry authorities for over a year, National Committee for Clinical Laboratory Standards (NCCLS) simplified the order of draw to function, regardless of the type of tubes being filled and regardless of whether a tube holder or syringe is used to collect the specimen. The order of draw is now as follows:

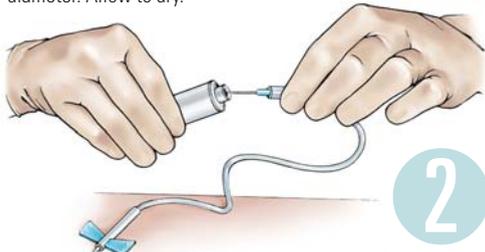
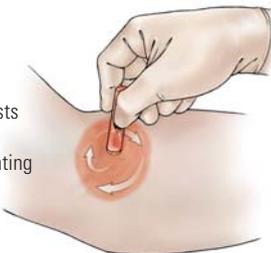
- 1 Sterile tubes for cultures
- 2 Sodium citrate tube (blue stopper)
- 3 Serum tube (with or without clot activator or gel; e.g., red-gold- or speckle-stopper)
- 4 Heparin tube (green stopper)
- 5 EDTA tube (lavender stopper)
- 6 Oxalate-fluoride tube (gray stopper)

Although NCCLS notes that glass nonadditive serum tubes can be drawn before the citrate tube, it simplified the order above to function for all serum tubes, regardless of content.

Tips on collection technique

1

Proper site cleansing consists of a 30- to 60-second scrub with the antiseptic, terminating with a final swabbing that starts from the intended puncture site and moves outward in circles of increasing diameter. Allow to dry.



2

When using a winged infusion set, always attach a tube holder onto the Luer adapter end to prevent an accidental needlestick.

3

Stretch the skin over the intended puncture site by pulling down with the thumb of your nondominant hand; then insert the needle at a low angle.



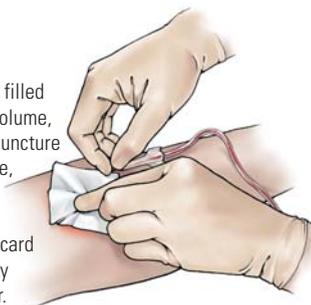
Once the vein is accessed, depress the tube holder onto the cap to the bottle, piercing the stopper. Fill with 10 mL to 12 mL of blood.

4



5

When both bottles are filled to the recommended volume, place gauze over the puncture site, remove the needle, and apply pressure. Activate the device's safety feature, and discard the needle immediately into a sharps container.



safety transfer device and inoculate the culture bottles. Blood should not be forcefully evacuated from a syringe into culture bottles or any specimen tubes. This risks exposure to bloodborne pathogens if a specimen splatters.

The collector should allow the vacuum to pull the recommended volume of blood into the broth. Overfilling, however, can lead to false-positive results. To understand this consequence, one must understand how some automated systems detect growth. When bacteria multiply, they raise the concentration of CO₂ in the bottle's internal environment. Systems that measure changes in the CO₂ levels during incubation periodically monitor concentrations and compare them to the baseline levels taken when the bottle was initially loaded. When a threshold of change is exceeded, the instrument alerts the operator that a positive vial has been detected. White blood cells, however, produce minute amounts of CO₂. If collectors become inattentive, and more than the maximum recommended volume is evacuated into a bottle, the excess of WBCs can trigger alerts and force unnecessary confirmatory testing.

Collecting inadequate volumes. The optimal volume for blood-culture collections from adults is considered to be 20 mL per blood per set, distributed between two bottles, and not to exceed 12 cc per vial for reasons already discussed. Collecting volumes less than this amount reduces the potential to harvest organisms causing septicemia. If the collection yields less than the minimum volume after drawing both aerobic and anaerobic bottles, evacuating up to the maximum recommended volume into the aerobic bottle is preferred over dividing lesser amounts between two bottles.

If a second blood culture is ordered, it may be appropriate to collect it immediately after the first one if it can be drawn from another site. Otherwise, a 45-minute wait before collecting the second set from the same site is recommended. The rationale here is that sampling from two completely different bloodstreams increases the likelihood of capturing sparse and transient populations of microorganisms.

Regardless of the equipment used for the collection, if other lab work is being collected simultaneously, evacuate blood into blood-culture bottles first and then fill the other lab tubes according to NCCLS' recommended order of draw.⁹ To reverse the order is to contaminate the needle.

Proper equipment, correct technique, and a designated team of phlebotomists can significantly reduce a facility's blood-culture contamination rate. If facilities employ these factors individually or in combination, it is reasonable to expect that fewer patients will be subjected to the human and financial costs associated with contaminated cultures. The laboratorian's challenge is to educate healthcare professionals from other disciplines to use good collection technique and prepare collection sites aseptically when performing phlebotomy in their patients. □

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