Infection Prevention and Control
Skills Station Series

Use of Simulation to Promote Best Practice for Obtaining Blood Cultures

March 2023

Kirsten Trudeau MSN APRN FNP-C
Advanced Practice Provider
Kentucky Infection Prevention Training and Education Center (KyIP)
Norton Healthcare, Louisville KY
Kirsten.Trudeau@nortonhealthcare.org

The contents of this packet include fundamental core infection prevention and control concepts. Simulation scenarios outlined in this packet were developed by the Kentucky Infection Prevention Training Center (KyIP) using fundamental core infection prevention and control concepts in collaboration with the Center for Diseases and Control's (CDC's) Project Firstline training initiative.

TABLE OF CONTENTS

INTRODUCTION TO PROJECT FIRSTLINE 4
About Project First Line 4
The Concept of Infection Control 4
Risk Recognition 5
What are Reservoirs? 6
Project Firstline Video Vlogs: Do We Really Have to Talk About Hand Hygiene? Again? Yes! 7
Health Equity Guiding Principles for Inclusive Communication 7
INTRODUCING SIMULATION AS A TOOL IN INFECTION PREVENTION EDUCATION AND TRAINING 8
TITLE: USE OF SIMULATION TO PROMOTE BEST PRACTICE FOR OBTAINING BLOOD CULTURES 9
LEARNING OBJECTIVES: AT THE END OF THIS SKILL STATION, PARTICIPANTS WILL: 9
PRE-BRIEF (Background) 10
What is a blood culture? 10
How do blood cultures guide patient management? 10
What is the impact of blood culture contamination in healthcare? 11
How do blood cultures get contaminated? 11
How can blood culture contamination be prevented? 11
Is there a national standard for blood culture contamination rates? 12
What is the relationship between blood culture contamination and antibiotic stewardship? 12
When should blood cultures be drawn for most accurate results? 13
How can amount blood volume collected for the culture impact growth? 13
Dos and Don'ts of Blood Culture Collection 13
Steps for proper blood culture collection *peripherally*: 14
Procedure Preparation: 14
Procedure for using butterfly and adapter 15
Procedure for using syringe and transfer device 15
Steps for drawing blood cultures from a central line or PICC line*: 15
SIMULATION 16
Workflow for Simulations 17
Simulation #1: Skin Antisepsis 17
Simulation #2: Improper Scrubbing Technique 18
Simulation # 3: Blood volume 19
Simulation #4: Contamination Rates 19

Debrief 20
Simulation #1 Discussion 21
Key Take Home Points 21
Simulation #2 Discussion 21
Key Take Home Points 22
Simulation #3 Discussion 22
Key Take Home Points 22
Simulation #4 Discussion 22
Key Take Home Points 23
Evaluation 23
APPENDIX 23
Blood Culture 2.1-Improper versus Proper Technique 23
Blood Culture 3.1- Hospital Toolkit for Adult Sepsis Surveillance 24
Blood Culture 4.1 -Debrief PEARLS tool 25
Blood Culture 4.2 -Debrief PEARLS tool 25
Blood Culture 5.1-Germs Live on Skin 26
Blood Culture 5.2-Germs Can Live on Dry Surfaces 27
Blood Culture 5.3-Germs Can Live in Blood 28
Skills Stations Evaluation (Learner): 29
Skills Stations Evaluation (Facilitator): 30
References 31

INTRODUCTION TO PROJECT FIRSTLINE

About Project First Line

Project Firstline is a national collaborative led by the U.S. Centers for Disease Control and Prevention (CDC) to provide infection control training and education to frontline healthcare workers and public health personnel. The **Kentucky Infection Prevention Training Center** is proud to partner with the **Kentucky Department of Public Health** and **Project Firstline**. Funding for the Kentucky Infection Prevention Training Center (KyIP) is provided through the CDC Epidemiology and Laboratory Capacity (ELC) Enhancing Detection grant supplement award to the Kentucky Department for Public Health (KDPH). CDC is an agency within the Department of Health and Human Services (HHS). The contents of this simulation skill packets do not necessarily represent the policies of CDC or HHS and should not be considered an endorsement by the Federal Government.

Project Firstline provides innovative and accessible infection control education for all frontline healthcare workers – so they can protect their patients, their coworkers and themselves from infectious disease threats in health care. As a collaborative, Project Firstline brings together more than 75 healthcare, academic, and public health partners to reach a wide range of healthcare audiences and settings across the country. Project Firstline offers educational resources in a variety of formats to meet the diverse learning needs and preferences of the healthcare workforce. **Resources are designed using adult learning principles, educational best practices, CDC recommendations, and the science that informs them**.

Link to About Project Firstline: https://youtu.be/PUjZlV_Iw-I

The Concept of Infection Control

The goal of everything we do in infection control, for any disease, is to keep people from getting sick. The goal of Project Firstline is to make sure you have the infection control knowledge that you need and deserve to keep yourself, your patients, your colleagues, and your family safe.

Link to: What is the goal of infection control video:

https://www.cdc.gov/infectioncontrol/projectfirstline/videos/Ep1-Goal-LowRes-New.mp4

Risk Recognition

Risk recognition is seeing the potential for a problem to happen. You see risk every day at home and at work, and you take steps to minimize it. You can help control infections in healthcare by learning to recognize the risks for germs to spread and cause infection, and not letting it happen. Healthcare is a unique setting – we consider germs differently in healthcare than we do in other places, like at home or in the community. The work that we do in healthcare presents many opportunities for germs to spread. Everyone, no matter your training or role, can recognize an infection risk and take action to keep germs from spreading.

No two days are the same in health care but caring for and protecting patients is always the top priority. This includes protecting patients from getting infections while they are receiving care. With a foundational knowledge about germ spread and the "why" behind infection control, you can recognize infection risks and make the right decisions to prevent people from getting sick, regardless of what the day brings.

Source: Recognize Infection Control Risks in Health Care | Project Firstline | CDC

Explore Project First line's educational content and resources to learn more about **where germs live in healthcare settings** and how to **recognize the risk** for them to spread – which is the first

step in understanding when to take action to protect your patients and yourself from infections.

Link to risk recognition in healthcare:
https://www.cdc.gov/infectioncontrol/projectfirstline/videos/RecognizeRisks-LowRes.mp4

As you're going about your workday, there are certain things that you are likely already doing to reduce the risk of spreading germs, like cleaning your hands between tasks or cleaning and disinfecting shared medical devices. *Standard Precautions* are the things you're doing, every day, for every patient, to keep germs from spreading. Because risks will always exist in healthcare settings, we follow these Standard Precautions to protect patients and ourselves — regardless of whether you know a patient has a specific infection – because often you don't know.

Recognizing infection risks goes beyond Standard Precautions. Because no two days in health care are ever the same, there will be moments when healthcare workers might need to apply infection control recommendations to situations that aren't usually described in guidelines. That's why understanding how germs spread and make people sick is so helpful – **it allows you to recognize infection risks throughout your workday, no matter the moment**.

What are Reservoirs?

"Reservoirs" are the places on and in our bodies and in the environment where germs live. Germs frequently spread between and among these reservoirs.

Four reservoirs in the human body that are important for infection control are

1. The skin;
2. The gastrointestinal (GI) system or "gut";
3. The respiratory system; and blood.

Understanding where germs live helps us recognize where there is risk for them to be spread, and helps us understand why infection control actions work to stop them from spreading and making people sick.

Project Firstline Video Vlogs: Do We Really Have to Talk About Hand Hygiene? Again? Yes!

Hand hygiene is essential for all aspects of infection control and prevention. In episode 21, Dr. Abby Carlson explains the importance of hand hygiene to prevent the spread of germs. After all, spreading germs makes yourself and patients more susceptible to infection.

https://www.cdc.gov/infectioncontrol/projectfirstline/videos/EP21-Hands-LowRes.mp4

Health Equity Guiding Principles for Inclusive Communication

The contents of this packet incorporates the CDC's Health Equity for Inclusive Communication. These principles are intended to help health communicators ensure that their communication products and strategies adapt to the specific cultural, linguistic, environmental, and historical situation of each population or audience of focus[10].

Link to Spanish resources: https://www.cdc.gov/infectioncontrol/projectfirstline/es/index.html

INTRODUCING SIMULATION AS A TOOL IN INFECTION PREVENTION EDUCATION AND TRAINING

Every day one out of every 31 hospitalized patients end up with a healthcare-associated infection (HAI). (CDC, 2021). This leads to an increased number of days hospitalized, a higher risk of mortality, and increased cost to the healthcare system. Unfortunately, HAIs have occurred in virtually all healthcare settings and have affected patients, residents, and healthcare workers. The ongoing rates of HAIs coupled with the challenges posed by the SARS-CoV-2 pandemic have underscored gaps in infection prevention practice and the need to refocus on basic principles of infection prevention.

The goal of the Infection Prevention Skills Stations Series is to provide opportunities for healthcare personnel to review basic infection prevention core practices and apply them through a variety of simulated learning experiences. Simulation is a process where situations encountered during healthcare can be represented, demonstrated, or performed using a variety of educational techniques. This approach serves as a connection between traditional classroom learning with real-world clinical experiences. The benefits of simulation learning include a range of learning opportunities, the ability to make mistakes without harm; the chance for evaluation and feedback, and the opportunity to practice a skill hands-on until proficient, and that is important for all healthcare workers (Society for Simulation in Healthcare, 2022). Participants in simulation can apply knowledge and critical thinking in situations that occur in all settings where healthcare is delivered including acute, long term, and ambulatory care and can be used with novice and experienced learners[5]. The key is to make simulations relevant to the individual.
This Skills Station will introduce you to the concept of simulation in healthcare, specifically in the areas of infection prevention (IP) and will focus on Blood Cultures. This simulation is designed to reach new and experienced learners in healthcare and seeks to create a fundamental understanding of infection prevention practices using scenarios that will show how various healthcare interactions, even those seemingly small, can lead to devastating complications and negative outcomes. Our hope is that this simulation can be used routinely as part of healthcare education and training, and ultimately decrease HAIs.

This Skills Station is organized into the following six sections:

1. The name or topic of the simulation is aligned with areas of practice or outcomes included in the Centers for Disease Control and Prevention (CDC) Core Infection Prevention and Control Practices for Safe Healthcare Delivery in all Settings—Recommendations of the HICPAC[11].
2. Learning objectives are outlined at the beginning of each Skills Station to define the problem and outline intended outcomes for the learner.

3. Each station will be structured into Pre-brief, Simulation, and Debrief segments and designed to take approximately one hour. Now, remember your audience. For novice and beginner learners, education or pre-briefing may be better assigned prior to coming into the simulation and having a quick recap to Pre-brief before the simulation session. For more proficient or expert learners, the Pre-brief may only need to occur right before the simulation begins. Debriefing is the most critical part of the process and should be the segment where sufficient time is devoted for engagement, interaction, and reflection. The Skills Stations have been structured with information for each section to standardize and streamline the process. A variety of simulation approaches have been incorporated across the Series and include video demonstrations, role playing scripts, games, group interactions, and instructions for return demonstrations.
4. A list of supplies needed for the individual Skills Station is provided. If expired supplies are used, it is vital that those supplies remain separated from supplies that will be used in actual patient care situations.
5. The workflow process for each Skills Station is included to help organize the learning session. A suggested time flow for the simulation, and specifics regarding each of the segments, is included in the section below.
6. Evaluation of performance of the learners as well as their perceptions of the experience are important to capture. This information may assist with additions or improvement to the process and serve to demonstrate value to the use of simulation for infection prevention practice for front-line healthcare workers.

TITLE: USE OF SIMULATION TO PROMOTE BEST PRACTICE FOR OBTAINING BLOOD CULTURES

LEARNING OBJECTIVES: AT THE END OF THIS SKILL STATION, PARTICIPANTS WILL:

1. Define what a blood culture is and how it is used for diagnostic and treatment planning.
2. Recognize the impact of blood culture contamination on patients and the healthcare system as a whole.
3. Analyze the relationship between blood culture contamination and antibiotic stewardship.
4. Apply actions that will prevent blood culture contamination.
5. Demonstrate proper method for blood culture collection in regards to technique, volume, and timing.

PRE-BRIEF (BACKGROUND)

What is a blood culture?

A blood culture is a sample of blood drawn from the patient that is placed in media and monitored for growth. Growth of bacteria would likely indicate the patient has bacteria in their blood. However, contamination of these samples is major problem. Blood cultures are most often done to look for aerobic and anaerobic bacteria using special media in blood culture bottles. Typically broth media is used (Magadia & Weinstein, 2001). Fungal blood cultures that are collected less often. Blood cultures are important diagnostic tools in patient presentations concerning for bacteremia, particularly, but not limited to sepsis. Blood cultures can guide the diagnostic and treatment plan. (Doern, 2021). It is ideal and best practice to obtain blood cultures prior to the start of antimicrobial therapy (CDC, n.d).

How do blood cultures guide patient management?

When bacteremia is suspected, diagnosis and treatment will depend on the organism causing the infection (AHRQ, 2019). The provider will look at the clinical significance of the organism growing. Because blood culture contaminants can be an issue, providers compare the growth of organisms commonly found in contaminants to the patient's clinical picture (Doern, 2021). If the organism(s) growing are clinically significant or clinically correlated, the provider should choose the narrowest spectrum antibiotic agents for the shortest duration that will effectively treat the infection. Below is a list of organisms and how to interpret the significance of their presence in a blood culture.

Always clinically significant	**Typically contaminant, but should check for clinical correlation**
S. aureus	Coagulase-negative staphylococci (except *Staphylococcus lugdunensis*, this is typically clinically significant)
Streptococcus pneumoniae	*Corynebacterium* species
Group A *Streptococcus*	*Cutibacterium acnes*
Enterobacteriaceae	*Bacillus* species (except *B. anthracis*, which is a clinically significant pathogen)
Haemophilus influenzae	*Micrococcus* species
Pseudomonas aeruginosa	
Bacteroidaceae	
Candida species	

(Doern, 2021)

What is the impact of blood culture contamination in healthcare?

Contamination of blood cultures is a significant problem in healthcare. In a study by Pien et al (2010), 41% of 2669 positive cultures were contaminated. Contamination can be prevented. If not prevented, a patient that has a positive blood culture due to contamination is subject to antibiotics they do not need and potentially a longer hospital stay (CDC, n.d.). A true infection cannot be ruled out without doing follow-up blood cultures (Doern, 2021). This can cause the patient to be exposed to unnecessary antibiotics that place them at risk for other harm. Secondarily, unnecessary antibiotic use can lead to resistance (CDC, 2021).

How do blood cultures get contaminated?

Contamination of the blood culture can occur at two major steps in the collection process. First, and the most likely source of contamination occurs at the time of the venipuncture. A discussed above, skin is a major reservoir for germs. See **Appendix-Blood Culture 5.1.** Inadequate skin disinfection results in skin flora contaminating the blood that is collected. The second most likely action contaminating the blood culture occurs at the time the blood is transferred into the culture bottle. This occurs due to inadequate disinfection of the rubber diaphragm on the top of the collection bottle. Because germs can live on dry surfaces (see **Appendix-Blood Culture 5.2**), germs can easily be sitting on the rubber diaphragm or transferred from one object onto the equipment or diaphragm. If cultures are collected through an existing intravascular device, such as a central line, contamination may occur when blood is collected through an inadequately disinfected access port. Collection from indwelling catheters have shown up to a 2.69 fold greater probability of contamination.

(Doern, 2019)

How can blood culture contamination be prevented?

There are a series of practice improvements that can impact the overall rates of blood culture contamination. The American Society of Microbiology (ASM) has outlined these areas: patient selection, skin antisepsis, bottle culture bottle disinfection, blood culture selection site, sterile gloves and hand hygiene, blood culture kits and standard procedures, blood sampling volume, phlebotomy teams/education, surveillance and feedback, and initial specimen diversion (Doern, 2019).

- Use of bacteremia prediction models to aid clinical decision making, ultimately decreasing the number of blood cultures ordered on patients with low probability of bacteremia.
- Skin antisepsis at the phlebotomy site with 2% alcoholic chlorohexidine or 70% isopropyl alcohol, followed by 2% chlorhexidine. Allow at least 30 seconds for dry time.

- Disinfect the rubber diaphragm of the blood culture vials with at least 70% isopropyl alcohol.
- Blood cultures should routinely be collected from peripheral sites, not central lines or other intravascular access sites which increase the chance of contamination. There may be instances when the provider requests the cultures from the indwelling central catheter if that catheter is suspected to be the source of infection.
- Generally hand hygiene with clean nonsterile gloves are recommended. Sterile gloves should be used if re-palpation of the disinfected skin site in necessary.
- Blood culture kits and standard procedures for obtaining cultures have shown in studies to reduce contamination rates.
- For adults, a blood culture generally consists of two bottles, each needing 10 mL of blood. This set of culture bottles would need 20-30ml of blood per venipuncture.
- Establish a dedicated team of staff members to collect blood cultures and provide specialized education on blood culture collection.
- Surveillance and timely feedback specifically to the staff obtaining the cultures has been shown in multiple studies to improve contamination rates. A great resource for bacteremia (sepsis) surveillance can be found on the CDC website linked in the **Appendix-Blood Culture 3.1- Hospital Toolkit for Adult Sepsis Surveillance.**
- Blood culture contamination rates can be reduced by developing a blood culture bundle to improve compliance to processes and standardization (Minami et al, 2022).
- Blood cultures should be drawn first in regards to order of draw (CLSI, 2019).
- Blood cultures should be processed as soon as possible after specimen collection. They should be sent to lab promptly and never frozen or refrigerated (Kirn & Weinstein, 2013).
- Blood cultures should be drawn directly into blood culture bottles using a butterfly and an adapter whenever possible. This process decreases the risk of blood culture contamination through the transfer process (Baron et al, 2013).
- If cultures must be drawn from an indwelling central catheter, it is important to review your institution's policy on cap changes prior to obtaining the cultures. Some research suggests doing this a part of the process to obtain cultures from an indwelling catheter (Mathew et al, 2013).

Is there a national standard for blood culture contamination rates?

Contamination rates in adults should not exceed 3% per the American Society for Microbiology (ASM) and the Clinical Laboratory Standards Institute (CLSI). However, the CDC argues a target contamination rate of 1% is achievable when best practices such as those listed above are followed (CDC, n.d).

What is the relationship between blood culture contamination and antibiotic stewardship?

In the era of antibiotic stewardship, the goal is to reduce the use of antibiotics and ultimately decrease the antibiotic resistance of microbes. It is important to remember this, "Clinicians should strive to obtain blood cultures for the right patients, in the right settings, and at the right time," (CDC, n.d. pg. 2). If antibiotics are broadly started without obtaining blood cultures, the ability to de-escalate therapy becomes significantly harder. Furthermore, ordering blood cultures in patients with a low likelihood of bacteremia can ultimately lead to a false-positive culture (CDC, n.d.). In order to be a good steward of antibiotics, a provider or clinician must be a good steward or diagnostic tools first. It is essential that antibiotic stewardship and infection prevention personnel be in close communication with laboratory staff regarding tracking and reporting of contamination (CDC, n.d.).

When should blood cultures be drawn for most accurate results?

Blood is aseptically drawn into aerobic and anaerobic bottles for the isolation and identification of the etiologic agents of bacteremia. Two blood cultures collected from two separate and properly prepared sites (two venipunctures) in a 24-hour period is usually satisfactory for the recovery of any organisms present; however, certain conditions and circumstances may warrant the collection of blood cultures differently than this protocol. For concerns of subacute bacterial endocarditic collect of one set of blood cultures every eight hours for a total of three. Whenever possible draw blood cultures prior to initiation of antimicrobial therapy for all acute bacteremia cases. A set of blood cultures involves an aerobic and anaerobic specimen.

How can amount blood volume collected for the culture impact growth?

Blood is typically sterile unless bacteremia is suspected. See **Appendix Blood Culture 5.3-Germs Can Live in Blood** for more information. However, even blood containing microbes may have very low circulating levels making it difficult to capture via blood culture. Having too little volume decreases the sensitivity of the culture (Kirn & Weinstein, 2013). It is essential in adults to obtain 20mls (10ml for aerobic and 10ml for anaerobic) for the most accurate pathogen yield. This is how good technique will lead to better patient outcomes.

Dos and Don'ts of Blood Culture Collection

Dos	Don'ts
Blood cultures should be ordered when attempting to determine etiology of infection.	Order blood cultures routinely on every patient
Obtain cultures before starting antibiotics	Overfill or under fill blood culture bottles
Use proper skin antisepsis technique—using a vigorous back and for scrubbing motion with 2% chlorohexidine/70% alcohol pad.	Use alcohol only, and don't use a concentric scrub from inner to outer area of the site.

Choose peripheral sites for collection over indwelling lines	Draw blood cultures from indwelling lines without the clinicians specific order to do so
Disinfect the rubber diaphragm of the blood culture vial	Refrigerate or freeze blood cultures
Develop a team for blood culture collection	Allow your facility's contamination rate to extend past 3%
Create a standardized process for your facility	Draw multiple blood culture vials (beyond one anaerobic and one aerobic) from the same site
Provide surveillance and feedback on contamination rates	Forget to compare potential contaminated organisms to the clinical presentation of the patient.
Draw blood directly into the blood culture bottle using an initial diversion device if available	
Obtain adequate blood volume for each bottle to be filled and obtain blood cultures in accordance with specific provider instructions (e.g., time between cultures, number and type of bottles)	

(Doern et al, 2020)

Steps for proper blood culture collection *peripherally*:

Procedure Preparation:

1. Identify patient using two identifiers
2. Explain the procedure to the patient
3. Verify all needed supplies are available
4. Check blood culture bottles for expiration date and signs of contamination
5. Clean work area with a hospital approved disinfectant wipe. Allow to dry.
6. Clean hands and put on clean gloves
7. Mark the 10 mL fill mark on side of blood culture bottle. Note that vacuum in bottle will allows for excess blood to be drawn which could adversely affect results.
8. Remove caps from blood culture bottles.
9. Using a new alcohol prep pad (70% isopropyl) for each bottle, perform a 15 second scrub of the top of each bottle and allow to air dry
10. Apply tourniquet and select venipuncture site
11. Using chlorhexidine gluconate [CHG]/alcohol sponge, scrub the venipuncture site using back and forth motions for 30 seconds. Allow site to dry for a minimum of 30 seconds.
12. If patient is allergic to CHG use alcohol/povidone iodine prep sponge. Alcohol solutions should be used in a scrubbing back and forth method vigorously for 30 seconds.

Povidine iodine is done in a circular motion. Starting at the venipuncture site using concentric motion, prep the site for 30-45 seconds. Allow site to air dry.

13. DO NOT TOUCH VENIPUNCTURE SITE AFTER PREPPING AREA

Procedure for using butterfly and adapter

1. Attach butterfly to blood culture collection adapter
2. Perform venipuncture
3. Push the adapter over the top of the **aerobic** blood culture bottle (it is okay for air from the collection tube to get into an aerobic bottle). Keep the blood culture bottle up right during collection. When blood is drawn to the appropriate mark, remove the blood culture bottle.
4. Push the adapter over the top of the **anaerobic** blood culture bottle and follow the process above (it is important to keep air out of the anaerobic tube).
5. Release tourniquet, remove butterfly and active safety feature while applying pressure to the site.
6. Mix the bottles by inverting gently

Procedure for using syringe and transfer device

1. Perform venipuncture using syringe and withdraw 20 mL of blood
2. Release tourniquet, remove needle and activate safety feature. Apply pressure to the site.
3. Remove the safety activated needle from the syringe taking care to avoid touching the tip of the syringe containing the blood that has been collected.
4. Place transfer device on syringe ensuring the end that will be connected to the syringe and the device that will pierce the top of the blood culture bottle remain sterile.
5. Using transfer device and syringe, add blood to the **anaerobe** bottle first (this allows the air to stay out of the anaerobic bottle). Allow the vacuum in the bottle to draw in 10 mL of blood. Remove syringe from the transfer device taking care to avoid touching the exposed end.
6. Using a new transfer device, attach the syringe and add blood to the **aerobic** bottle (it is okay that the air in the syringe at the end gets into the aerobic bottle). Allow the vacuum in the bottle to draw in 10 mL of blood. Remove the transfer device and syringe and immediately place in sharps container.
7. Take care during this process to not touch or otherwise contaminate the syringe, transfer device or blood culture bottle.
8. Mix the bottle by inverting gently.
14. Label specimen in front of patient verifying by using 2 patient identifiers.
15. Place in biohazardous bag for transport to lab.

Steps for drawing blood cultures from a central line or PICC line*:

*Remember this method is on a clinician based order only. It is not routine or best practice to draw blood cultures from an indwelling line. Best practice requires obtaining peripheral blood cultures.

1. Identify patient using two identifiers.
2. Explain the procedure to the patient.
3. Verify all supplies are available.
4. Check blood culture bottles for expiration date and signs of contamination.
5. Prepare work area by using a germicide wipe and allow to dry.
6. Perform hand hygiene and don sterile gloves.
7. Perform a sterile cap change on the needleless access device (NAD) on the line prior to obtaining cultures (Mathew et al, 2009).
8. Remove gloves.
9. Perform hand hygiene and don clean, non-sterile gloves.
10. Scrub the NAD with 70% isopropyl
11. Attached a sterile syringe to the NAD making sure the syringe is large enough to obtain the volume of blood needed to fill the blood culture bottles.
12. Withdrawal 20ml of blood.
13. Disconnect syringe.
14. Using transfer device and syringe, add blood to the **anaerobe** bottle first (this allows the air to stay out of the anaerobic bottle). Allow the vacuum in the bottle to draw in 10 mL of blood
15. Using transfer device and syringe, add blood to the **aerobic** bottle (it is okay with the air in the syringe at the end gets into the aerobic bottle). Allow the vacuum in the bottle to draw in 10 mL of blood.
16. Take care during this process to not touch or otherwise contaminate the syringe, transfer device or blood culture bottle.
17. Mix the bottle by inverting gently.
18. Remove gloves. Perform hand hygiene.
19. Don new non-sterile clean gloves.
20. Scrub the NAD.
21. Use 10ml preservative-free normal saline to flush the catheter using the push-pause method. Follow institution policy regarding use of saline or heparin flush for the device.
22. Label specimen in front of patient verifying by using 2 patient identifiers.
23. Place in biohazardous bag for transport to lab.

(Adapted from Cox, K., n.d.)

SIMULATION

Workflow for Simulations

- Test all virtual connections including those with learners as well as video access
- Have all videos open and available for rapid and sequential access to minimize downtime during the simulation
- Have resources available in PowerPoint format with ability to share screen with virtual learners, or have paper copies if needed for in-person learners. You want all learners to indicate their responses for the scenario questions during Simulations 2 and 4, so determine how to best capture this information. Polling questions, self-reported scores in Zoom chat, verbal responses, or written submissions are examples of methods that can be used.
- Go through each simulation and perform a Debrief following all videos, discussions, and scenario responses
- Use the PEARLS Debriefing Tool to help guide the discussion. The goals with the debriefing include:
    - Learner reactions to the simulations
    - Clarifications, if needed
    - How the simulations impact current practices, or not
    - Challenges to performance
    - Additional comments from learners
    - Takeaway points

Key learning points (review the objectives)

Simulation #1: Skin Antisepsis

During this simulation the blood culture video #1 will be shown prepping to obtain blood cultures from three different sites with proper and improper skin antisepsis to show contamination risks. Proper skin antisepsis should consist of a 2% CHG/70% alcohol prep sponge scrub for 30 seconds of back and forth vigorous scrubbing.

For this simulation, follow these steps:

1. Place fluorescein oil on mannequin skin in three different locations
2. Have learner prep three sites for blood culture procedure
    a. One location clean with CHG as advised-for 30 seconds vigorous scrubbing
    b. The next only clean for 10 seconds
    c. Last site, do not clean at all
3. Obtain “blood samples” and put in respective labeled bottles
4. Evaluate the sites as well as the blood culture bottles with black light

Audience:
For **in-person**, the instructor will then show the various sites of blood culture collection based on how long skin antisepsis was performed. The learners will provide feedback on the implications of poor skin antisepsis on blood cultures contamination.

For **virtual**, show Blood Culture #1 Video and Blood Culture #2 still photos. Virtual learners will use the chat function to provide feedback on the implications of poor skin antisepsis and contaminated blood cultures.

Supplies Needed:
Mannequin arm, 2% CHG/70% alcohol prep sponge, 2 Blood culture safety adapter (transfer devices), Three blood culture vials, Alcohol prep pads, Gloves, Fluorescein oil, Sterile syringes, Video #1, Equipment to show video in-person or virtually, Live or virtual connection with learners, Mechanism for learners to take notes, PEARLS Healthcare Debriefing Tool for Simulation leader

Suggested time flow for simulation: 10 minutes

Simulation #2: Improper Scrubbing Technique

During this simulation, Blood Culture Video #2 will be shown. Blood culture technique will be reviewed. Best practice is to disinfect the rubber diaphragm of the blood culture vials with 70% alcohol sterile pad.

For this simulation:
Two blood culture bottles will be used for example. Place 1ml of fluorescein oil in one blood culture vial. For the same vial prep the rubber diaphragm of the blood culture vial with fluorescein oil. This is the bottle that will not be disinfected. Disinfect the second vial with a 70% sterile alcohol swab. Label the bottles as non-disinfected and disinfected respectively. Instructor will point out that the rubber diaphragm of both blood culture vials. The fluorescein oil will show the germs on the non-disinfected (no scrub) and no oil on the vial properly disinfected. Learners will answer quiz questions on improper versus proper technique found in **Appendix-Blood Culture 2.1**.

Audience:

For **in-person:** allow leaners to practice cleaning one blood culture vial. Instructor will show diaphragms under UV light to show the disinfected verse the non-disinfected. Facilitate a discussion about a contaminated rubber diaphragm and blood culture contamination.

For **virtual:** Show Blood Culture Video #3 and Blood Culture Photo #2. Facilitate a discussion about a contaminated rubber diaphragm and blood culture contamination using the chat function.

Supplies Needed: Mannequin arm, 2% CHG/70% alcohol prep sponge, or 70% alcohol/povidone prep sponge, Blood culture safety adapter (transfer device), two blood culture vials, Alcohol prep pads, Gloves, Fluorescein oil, Sterile syringes, blunt tip needles x 2, Video #2. Equipment to show video in-person or virtually, Live or virtual connection with

learners, Resource questionnaire **Blood Culture 2.1-Improper versus Proper Technique,** Mechanism for learners to take notes, PEARLS Healthcare Debriefing Tool for Simulation leader.

Suggested time flow for simulation: 5 minutes

Simulation # 3: Blood volume

Blood Volume still series will be used showing proper and improper blood volumes in both syringes and blood culture vials. Learners will identify adequate versus inadequate volumes of blood for the sample collection through a matching game. Learners will discuss the relationship of blood volume and pathogen growth yield.

Audience:

For **in-person:** Prepare water and red food coloring mixture to create “blood”. Draw up three syringes with 5ml, 10ml, and 20ml respectively. Mark the blood culture bottles at the 10ml line. Have the learners transfer the “blood” into the blood culture vials showing the 20ml to use between two culture bottles. Because we are using syringes to collect and transfer, ensure the anaerobic vial is filled first to prevent air from getting into the the anaerobic vial. The instructor will encourage the visualization of the blood once in the vial and facilitate a discussion on adequate blood volume for germ growth.

For **virtual:** Show Blood Culture Photos # 3. Prepare the photos in a matching game of correct or incorrect blood volume in syringes and vials. The instructor will encourage the visualization of the blood once in the vial and facilitate a discussion on adequate blood volume for germ growth.

Supplies Needed: Three 20ml syringes, food coloring, water, three blood culture vials, sterile 70% alcohol prep pads, sterile drapes, and three sterile transfer devices. Blood Culture Volume still series, Equipment to show in-person or virtually, Live or virtual connection with learners, Mechanism for learners to take notes, PEARLS Healthcare Debriefing Tool for Simulation leader.

Suggested time flow for simulation: 5 minutes

Simulation #4: Contamination Rates

For this simulation, learners will receive a scenario.

Scenario: Your facility’s blood culture contamination rate is now 5%, which is up from the normal 2% contamination rate the facility usually sees. This contamination rate changed in one

month's time. The instructor will test the learner's knowledge on what level of contamination is acceptable.

Audience:
For **in-person** learners, break out into groups and role play as personnel from pharmacy (antibiotic stewardship), laboratory, and those that collect the blood cultures. Identify potential reasons for the increase, and create a plan to decrease the contamination back below 3%. Examine what this increased contamination rate means for antibiotic stewardship. Discuss the plans as a collective group and instructor provide feedback.

For **virtual** learners, break out into zoom break-out groups and role play as personnel from pharmacy (antibiotic stewardship), laboratory, and those that collect the blood cultures. Identify potential reasons for the increase, and create a plan to decrease the contamination back below 3%. Examine what this increased contamination rate means for antibiotic stewardship. After 10 minutes, return from breakout room. Discuss the plans as a collective group and instructor provide feedback.

Supplies Needed: Live or virtual connection with learners, Ability to break learners into groups, Mechanism for learners to take notes, PEARLS Healthcare Debriefing Tool for Simulation leader

Suggested time flow for simulation: 15 minutes

DEBRIEF

1. Set the scene by reviewing the simulation. Use the PEARLS Healthcare Debriefing Tool (**Appendix-Blood Culture 4.1 and 4.2**) to open the discussion. Tools are provided in the Appendices**.**
2. Ask for reactions and use learner responses gathered during the Simulation discussion to probe further.
3. Describe situations in the scenario that seem to be points of confusion or discussion.
4. Analyze the simulation by asking some discussion questions:
    a. What went well and what would you change?
    b. Advocacy and Inquiry
        i. State your observation and opinion
        ii. Ask how the learner saw it
    c. Provide constructive feedback to close gaps in knowledge
    d. Prompts to consider
        i. "What errors did you identify?"
        ii. "What is the impact?"
        iii. "What practices may prevent this issue?"
        iv. "How far up the chain will you take this?"
        v. "How can Human Factors Engineering be applied to this issue?"

vi. What errors were identified?
vii. What went well?
viii. What would you change?
ix. What errors were identified?
x. What is the impact?
xi. What practices may prevent this issue?

5. Application and Summary
    a. Take-away points
        i. What did the learner take away?
        ii. What were the key learning points from the instructors view?

Simulation #1 Discussion

Initiate an open discussion with your group focused on:

What are the implications of improper skin antisepsis?

How can poor skin antisepsis affect the contamination rate in the hospital?

Why would poor skin antisepsis cause harm to the patient?

When would a blood culture mostly likely become contaminated?

What would be a potential benefit of using sterile gloves when collecting blood cultures?

Key Take Home Points

- Proper skin antisepsis at the phlebotomy site with 2% alcoholic chlorohexidine or 70% isopropyl alcohol, followed by 2% chlorhexidine is imperative. Chlorohexidine scrub requires a vigorous back and forth scrubbing motion. Allow at least 30 seconds for dry time.
- Skin antisepsis can prevent blood culture contamination.
- The use of sterile gloves in not required, but has been shown to decrease contamination rates when implemented in contamination reduction programs. Generally though, hand hygiene with clean nonsterile gloves are recommended. Sterile gloves should be used if re-palpation of the disinfected skin site in necessary.
- Because skin is a reservoir for germs, those germs can easily be transferred from the skin into the blood culture causing contamination.
- Contamination can lead to unnecessary antibiotic use causing harmful side effects for the patient and over increase in antibiotic resistance.

Simulation #2 Discussion

Initiate an open discussion with your group focused on:

Why is disinfecting the rubber diaphragm of the blood culture bottle important?

How do germs living on dry surfaces impact blood culture collection?

When would sterile gloves be recommended for use to obtain blood cultures, and **why?**

What is important about allowing alcohol to dry after scrubbing?

Key Take Home Points

- Disinfect the rubber diaphragm of the blood culture vials with at least 70% isopropyl alcohol.
- The alcohol must have time to dry prior to transferring the sample into the bottle through the rubber diaphragm.
- Choose peripheral sites for collection over indwelling lines unless instructed by a provider.
- Creating a standardized process for your facility will decrease the likelihood of error.
- The use of blood culture kits and standard procedures can decrease the risk of contamination.

Simulation #3 Discussion

Initiate an open discussion with your group focused on:

How does the volume of blood collected impact the pathogen growth yield?

What might be the implications of obtaining too little volume for the blood culture?

When would it most appropriate to rule out bacteremia and stop drawing blood cultures?

Why would having a minimum amount of blood volume required for blood culture collection ultimately help aid in the fight against antibiotic resistance?

Key Take Home Points

- Adequate blood volume is imperative. Having too little volume decreases the sensitivity of the culture.
- It is essential in adults to obtain 20mls (10ml for aerobic and 10ml for anaerobic) for the most accurate pathogen yield.
- Two blood cultures collected from two separate and properly prepared sites (two venipunctures) in a 24-hour period is usually satisfactory with special considerations for conditions like endocarditis.

Simulation #4 Discussion

Initiate an open discussion with your group focused on:

What errors did your group identify as possible reasons for the increased contamination rate?

How can following guidelines on appropriate ordering of blood cultures have an impact on contamination rates and antibiotic stewardship?

What action plan has your group created?

When do you plan to deploy this action plan for future occurrences of an increased contamination rate?

What is the relationship between blood culture contamination control and antibiotic stewardship?

Key Take Home Points

- The contamination rate should remain below 3%, however; the CDC states with the proper techniques and protocols that a <1% contamination rate is possible.
- Blood culture contamination can result in unnecessary antibiotic use until repeat cultures can grow.
- Obtaining blood cultures before starting antibiotics is key to finding the best antibiotic to treat the pathogen. Starting broad spectrum without cultures can make it difficult to narrow and ultimately increase the risk of antibiotic resistance.
- Knowing the dos and don'ts of blood culture collection will help keep contamination rates down.
- A standardized approach, the use of kits, and a dedicated team of people that draws the blood cultures are all ways to decrease the contamination rate.

EVALUATION

The evaluation method will involve determination of reaction (how learners felt about the experience), learning (did the learner gain knowledge from the experience), behavior (was the learner able to apply the knowledge), and results (impact of the training on learner's practice.

To gather evaluation information, the standard evaluation tool will be used for all Skill Stations learners within this series. An additional evaluation tool is available for sessions provided for facilitators.

APPENDIX

Blood Culture 2.1-Improper versus Proper Technique

1. **Blood cultures routinely drawn from peripheral sites.**

Proper Technique	Improper Technique

2. **Using CHG/alcohol sponge, scrub the venipuncture site using back and forth motions for 30 seconds. Allow site to dry for a minimum of 30 seconds.**

Proper Technique	Improper Technique

3. **Repalpating the site wearing clean non-sterile gloves after skin antisepsis is performed.**

Proper Technique	Improper Technique

4. **Obtaining at least 10ml of blood per culture bottle.**

Proper Technique	Improper Technique

5. **Using 70% isopropyl alcohol pad to disinfect the rubber diaphragm of the blood culture vial and allow to dry.**

Proper Technique	Improper Technique

6. **Holding on to the end of the syringe as you connect the transfer device to ensure a good connection.**

Proper Technique	Improper Technique

7. **If unable to get specimen to lab immediately after collection, place in freezer until transport.**

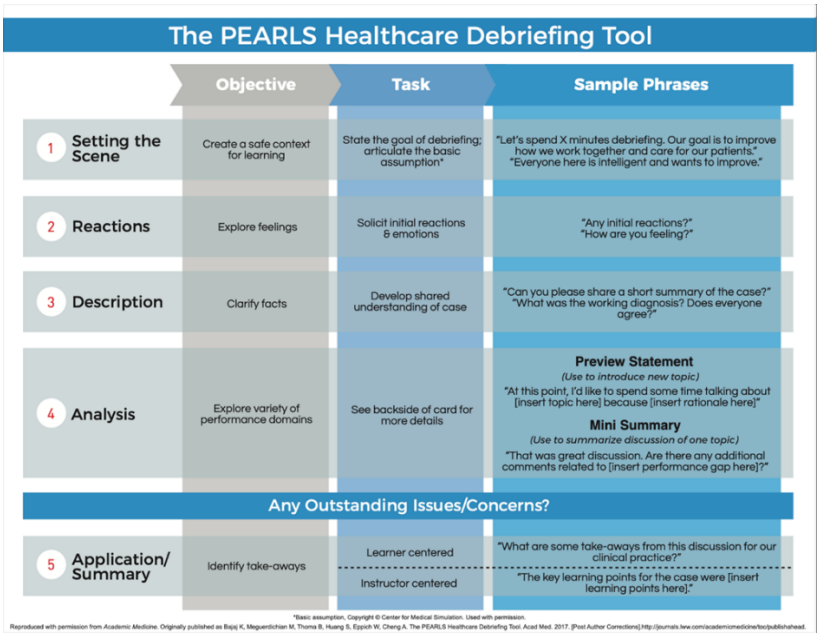
Proper Technique	Improper Technique

Answers: 1) Proper **2)** Proper **3)** Improper **4)** Proper **5)** Proper **6)** Improper **7)** Improper

Blood Culture 3.1- Hospital Toolkit for Adult Sepsis Surveillance

[Hospital Toolkit for Adult Sepsis Surveillance (cdc.gov)]

Blood Culture 4.1 -Debrief PEARLS tool

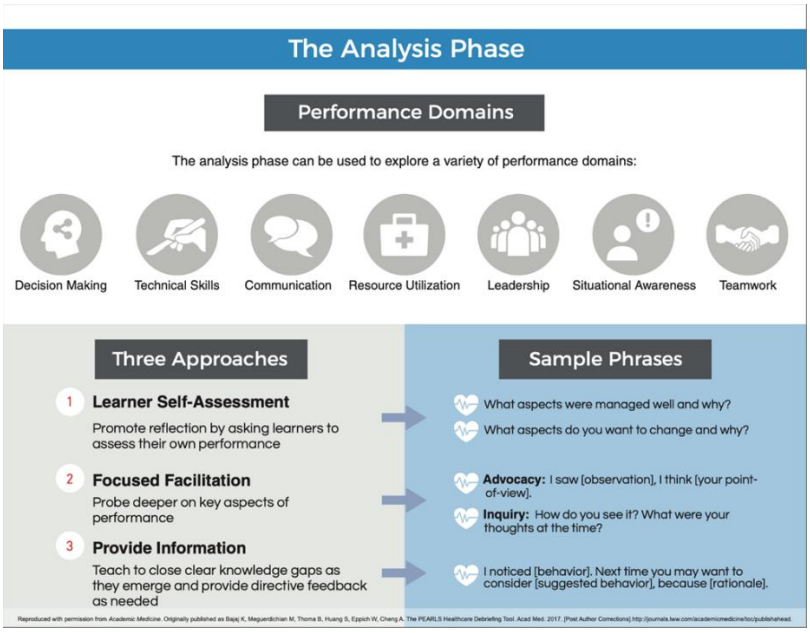


The PEARLS Healthcare Debriefing Tool

	Objective	Task	Sample Phrases
1 Setting the Scene	Create a safe context for learning	State the goal of debriefing; articulate the basic assumption*	"Let's spend X minutes debriefing. Our goal is to improve how we work together and care for our patients." "Everyone here is intelligent and wants to improve."
2 Reactions	Explore feelings	Solicit initial reactions & emotions	"Any initial reactions?" "How are you feeling?"
3 Description	Clarify facts	Develop shared understanding of case	"Can you please share a short summary of the case?" "What was the working diagnosis? Does everyone agree?"
4 Analysis	Explore variety of performance domains	See backside of card for more details	**Preview Statement** *(Use to introduce new topic)* "At this point, I'd like to spend some time talking about [insert topic here] because [insert rationale here]" **Mini Summary** *(Use to summarize discussion of one topic)* "That was great discussion. Are there any additional comments related to [insert performance gap here]?"
Any Outstanding Issues/Concerns?			
5 Application/ Summary	Identify take-aways	Learner centered / Instructor centered	"What are some take-aways from this discussion for our clinical practice?" "The key learning points for the case were [insert learning points here]."

*Basic assumption, Copyright © Center for Medical Simulation. Used with permission.

Blood Culture 4.2 -Debrief PEARLS tool



The Analysis Phase

Performance Domains

The analysis phase can be used to explore a variety of performance domains:

Decision Making · Technical Skills · Communication · Resource Utilization · Leadership · Situational Awareness · Teamwork

Three Approaches	Sample Phrases
1 **Learner Self-Assessment** Promote reflection by asking learners to assess their own performance	What aspects were managed well and why? What aspects do you want to change and why?
2 **Focused Facilitation** Probe deeper on key aspects of performance	**Advocacy:** I saw [observation], I think [your point-of-view]. **Inquiry:** How do you see it? What were your thoughts at the time?
3 **Provide Information** Teach to close clear knowledge gaps as they emerge and provide directive feedback as needed	I noticed [behavior]. Next time you may want to consider [suggested behavior], because [rationale].

Blood Culture 5.1-Germs Live on Skin

Blood Culture 5.2-Germs Can Live on Dry Surfaces

Blood Culture 5.3-Germs Can Live in Blood

SKILLS STATIONS EVALUATION (LEARNER):

Simulation Topic: Blood Cultures Date: __ \ __\ ____

Circle your response to the following questions:

I was oriented to the purpose of this simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

The simulation experience was conducted in a skillful manner.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

The simulation experience provided me with new knowledge.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

The simulation experience provided me with an opportunity to apply my knowledge.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

My current practice differed from that demonstrated during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

I intend to apply what I learned during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

My practice will change based upon what I learned during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

I found the simulation experience to be beneficial to my practice.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

Comments:

SKILLS STATIONS EVALUATION (FACILITATOR):

Simulation Topic: Blood Cultures Date: __ \ __\ ____

Circle your response to the following questions:

I was oriented to the purpose of this simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

I was provided with adequate information so I can conduct the simulation experience in a skillful manner.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

The simulation experience provided me with new knowledge.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

The simulation experience provided me with an opportunity to apply my knowledge.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

My current practice differs from that demonstrated during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

I intend to apply what I learned during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

My teaching approach will change based upon what I learned during the simulation experience.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

I found the simulation experience to be beneficial to my role.

Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

Comments:

REFERENCES

American Society for Microbiology: Cumitech 1C, 2005 (EJ Baron *et al*.) ASM Press

Baron EJ, Miller JM, Weinstein MP, Richter SS, Gilligan PH, Thomson RB Jr, Bourbeau P, Carroll KC, Kehl SC, Dunne WM, Robinson-Dunn B, Schwartzman JD, Chapin KC, Snyder JW, Forbes BA, Patel R, Rosenblatt JE, Pritt BS. A guide to utilization of the microbiology laboratory for diagnosis of infectious diseases: 2013 recommendations by the Infectious Diseases Society of America (IDSA) and the American Society for Microbiology (ASM)(a). Clin Infect Dis. 2013 Aug;57(4):e22-e121. doi: 10.1093/cid/cit278. Epub 2013 Jul 10. PMID: 23845951; PMCID: PMC3719886.

Be Antibiotics Aware: Smart Use, Best Care. (2021). *CDC.* Retrieved from https://www.cdc.gov/patientsafety/features/be-antibiotics-aware.html#:~:text=When%20antibiotics%20aren%E2%80%99t%20needed%2C%20they%20won%E2%80%99t%20help%20you%2C,Yeast%20infections%20More%20serious%20side%20effects%20can%20include%3A Accessed on August 4, 2022.

Best Practices in the Diagnosis and Treatment of Bacteremia. (2019). *AHRQ.* 17(20)-0028-EF. Retrieved from https://www.ahrq.gov/antibiotic-use/acute-care/diagnosis/bacteremia.html Accessed on August 5, 2022.

Blood Culture Contamination: An Overview for Infection Control and Antibiotic Stewardship Programs Working with the Clinical Laboratory. (n.d). *CDC.* Retrieved from https://www.cdc.gov/antibiotic-use/core-elements/pdfs/FS-BloodCulture-508.pdf?ACSTrackingID=USCDC_426-DM86188&ACSTrackingLabel=Clinicians%3A%20Use%20this%20guide%20to%20decrease%20blood%20culture%20contamination%20rates&deliveryName=USCDC_426-DM86188. Accessed on July 20, 2022.

Center for Disease Control and Prevention (CDC). (2022). *Germs Can Live on Dry Surfaces.* CDC. Retrieved from Germs can live on dry surfaces (cdc.gov). Accessed January 20, 2023.

Clinical and Laboratory Standards Institute (CLSI®), document M47-A, Vol 27, 2007 (ML Wilson *et al*.)

Cox, K. (n.d.) Blood Sampling from a Central Venous Catheter. *Elsevier.* Procedure 62. 0071-ch0062-9780323376624.indd (elsevier.com)

Doern GV, Carroll KC, Diekema DJ, Garey KW, Rupp ME, Weinstein MP, Sexton DJ. 2019. A comprehensive update on the problem of blood culture contamination and a discussion of methods for addressing the problem. Clin Microbiol Rev 33:e00009-19. https://doi.org/10.1128/CMR.00009-19

Doern, G.V. (May 3, 2021). Detection of bactermia: Blood cultures and other diagnostic tests. *UpToDate.* https://www.uptodate.com/contents/detection-of-bacteremia-blood-cultures-and-

other-diagnostic-tests?search=blood%20culture%20procedure&source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1.Accessed on May 19, 2022.

Emergency Nurses Association (ENA). Clinical Practice Guideline: Prevention of Blood Culture Contamination. March 14, 2022. https://www.guidelinecentral.com/guideline/308349/ Accessed on May 19, 2022.

Hospital Toolkit for Adult Sepsis Surveillance. (2018). *CDC.* Retrieved from https://www.cdc.gov/sepsis/pdfs/Sepsis-Surveillance-Toolkit-Mar-2018_508.pdf

Kirn, T.J., Weinstein, M.P. (2013). Update on blood cultures: how to obtain, process, report, and interpret. *Clinical Microbiology and Infection. 19(6).* 513-520. https://www.sciencedirect.com/science/article/pii/S1198743X14615093#:~:text=Blood%20cultures%20entered%20into%20automated%2C%20continuous-monitoring%20protocols,should%20routinely%20be%20incubated%20for%205%20days.

Magadia, R., Weinstein, M. P. Laboratory Diagnosis of Bacteremia and Fungemia. (2001). *Infectious Disease Clinics of North America. 15:1 (1009-1024).* Retrieved from https://www.sciencedirect.com/science/article/pii/S0891552005701847?via%3Dihub Accessed on July 28, 2022.

Mathew, Alice MSN, RN, CRNI; Gaslin, Tracey PhD, RN, CPNP, CRNI®; Dunning, Kari PhD, PT; Ying, Jun PhD. Central Catheter Blood Sampling: The Impact of Changing the Needleless Caps Prior to Collection. Journal of Infusion Nursing: July 2009 - Volume 32 - Issue 4 - p 212-218 doi: 10.1097/NAN.0b013e3181aac20c

Minami, K., Yamada, T., Yoshioka, K., Kawanishi, F., Ogawa, T. & Ukimura, A. (2022). Effect of the introduction of a management bundle for blood culture collection. *AJIC: American Journal of Infection Control, 50(7).* 772-776. https://doi.org/10.1016/j.ajic.2021.11.019

Order of Blood Draw Tubes and Additives. (2019). *CLSI.* https://clsi.org/about/blog/order-of-blood-draw-tubes-and-additives/

Patel, K., Carval, T., Poojary, A., & Poojary, R. (2019). Impact of novel blood culture collection bundle to reduce blood culture contamination rates: An important continuous quality improvement indicator of laboratory medicine. *Journal of Patient Safety and Infection Control*, *7*(3), 65.

Pien BC, Sundaram P, Raoof N, Costa SF, Mirrett S, Woods CW, Reller LB, Weinstein MP. The clinical and prognostic importance of positive blood cultures in adults. Am J Med. 2010 Sep;123(9):819-28. doi: 10.1016/j.amjmed.2010.03.021. PMID: 20800151.

Procop, G. W., Nelson, S. K., Blond, B. J., Souers, R. J., & Massie, L. W. (2020). The Impact of Transit Times on the Detection of Bacterial Pathogens in Blood Cultures: A College of American Pathologists Q-Probes Study of 36 Institutions. *Archives of Pathology & Laboratory Medicine*, *144*(5), 564–571. https://doi.org/10.5858/arpa.2019-0258-CP

Tenderenda, A., Łysakowska, M., Dargiewicz, R., & Gawron-Skarbek, A. (2022). Blood Culture Contamination: A Single General Hospital Experience of 2-Year Retrospective Study. *International Journal of Environmental Research and Public Health*, *19*(5). https://doi.org/10.3390/ijerph19053009