June 30th, 2015

Blood Culture Contamination

Use of Diversion Systems for Control of Contamination

Introduction

Blood culture contamination remains a significant problem for hospitals in terms of patient care quality and financial costs. Contaminated blood cultures result directly in or prolong unnecessary treatment of patients with broad spectrum antibiotics. That treatment has a number of serious downstream consequences for patients that increase morbidity, length of stay, and can result in mortality.[1] The national average contamination rate has persisted at 3% with emergency departments often reporting the highest rates of contamination up to 12% in some cases.[2]

Diversion methods and systems present a unique strategy for control of blood culture contamination problems. Clean Collect® is a blood culture diversion system designed to prevent contamination by eliminating skin contaminants from initial blood flow before blood cultures are drawn.

This article will review the sources of contamination, diversion methods, and impact of reducing blood culture contamination rates at hospitals.

Sources of Contamination

Most contaminants derive from either skin bacteria or the environment. Certain sources of contaminants such as re-palpation and inadequate antiseptic use are well known and are often the target of educational efforts by hospital management. Other sources including subsurface bacteria and equipment contamination are less commonly discussed but can contribute significantly to blood culture contamination. Table 1 below describes the sources of contamination and estimated impact of each source.

"The costs of correcting a defective product often exceed the cost of designing a system to avoid producing the defect. For hospitals, these costs are not only monetary but also carry a burden of human suffering. The contaminant blood culture can be regarded as a defective product".[16]

Quote from:

Dr. Frederic Weinbaum, MD
Journal of Clinical Microbiology

Table 1 – Sources of Blood Culture Contamination

Source	Description	Impact
Re-palpation	Bacteria deposited on the surface of the skin from the blood collector's fingers or gloves before insertion of a needle or IV.	High
Subsurface skin bacteria	Bacteria colonized beneath the surface of the skin in sebaceous (oil) glands, sudoriferous (sweat) glands, or subsurface portions of hair follicles.	Medium
Inadequate antiseptic use	Bacteria persisting on the surface of the skin after antiseptic use due to inadequate scrubbing , application time , or drying time.	Medium
Equipment and process	Bacteria transferred from the environment onto equipment such as luer adaptors or syringes during the collection process.	Medium
Transient bacteremia	Bacteria transiently present in the patient's blood that is not associated with sepsis or another disease.	Low

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Sources of Contamination (Illustrated)

The impact of each source of contamination varies by department, personnel, and collection method. Peripheral blood cultures are often collected by trained phlebotomists and generally have a lower contamination rate with an average of 2.2%.[2] Blood cultures drawn through IVs are typically collected by emergency department nurses in the course of IV placement. These blood cultures are more susceptible to several forms of contamination and average 6.5% contamination.[3] The sources of contamination are described in more detail below.

Inadequate Antiseptic Application

Chlorhexidine gluconate is the most commonly used antiseptic for skin preparation prior to blood culture collection. Chlorhexidine was developed for use on skin and is less potent than antiseptics such as bleach that are used on general surfaces. Chlorhexidine requires significant application force and drying time in order to effectively kill bacteria on the skin's surface. Failure to thoroughly scrub with chlorhexidine or dry the skin can leave viable bacteria on the surface when a needle is inserted.

Re-palpation

Emergency department nurses often re-palpate prior to insertion of IVs. This practice has proven difficult to correct for prolonged periods since avoiding re-palpation reduces accuracy which leads to multiple attempts to place IVs and patient dissatisfaction.

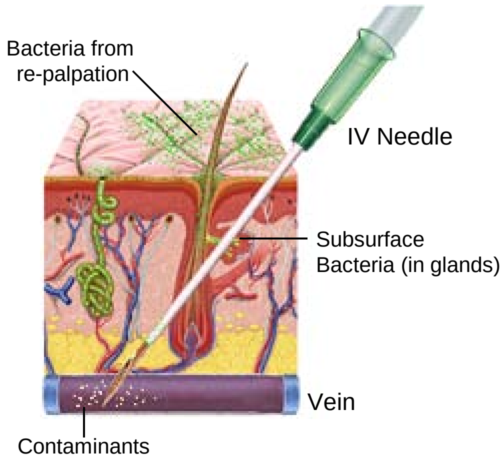


Figure 1
Subsurface bacteria and other common sources of contamination

Figure 2
Contamination of a syringe or luer lock device during blood culture collection

Subsurface Skin Bacteria

Bacteria normally colonize the skin beneath the surface with the highest concentration in sebaceous glands and the sub-surface portions of hair follicles as shown in Figure 1. Killing bacteria in sub-surface locations with antiseptics is not generally feasible.

Equipment Contamination

Hospitals reporting the highest contamination rates tend to use syringes frequently for blood culture collection. When syringes are disconnected from IVs, the luer end is left open and can be brushed against the patient's arm, bedsheets, or nurse's clothing resulting in contamination. This problem is compounded when multiple syringes are used to draw the 20mLs of blood required for blood cultures and additional amounts for other tests. Luer lock devices used to draw directly from IVs can be contaminated in a similar way to syringes as shown in Figure 2.

Significance

The most commonly recovered contaminant in blood cultures from these sources is *Staphylococcus epidermidis*, Previously, *S. epidermidis* was often presumed to be a skin contaminant. However, growing use of IV catheters and other indwelling lines have resulted in the emergence of *S. epidermidis* as the leading cause of nosocomial infections.[4] *S. epidermidis* continues to be the most frequent pathogen identified in cases of cellulitis. The growth of *S. epidermidis* and other skin bacteria in blood cultures cannot simply be dismissed as a contaminant without serious potential consequences for the patient.

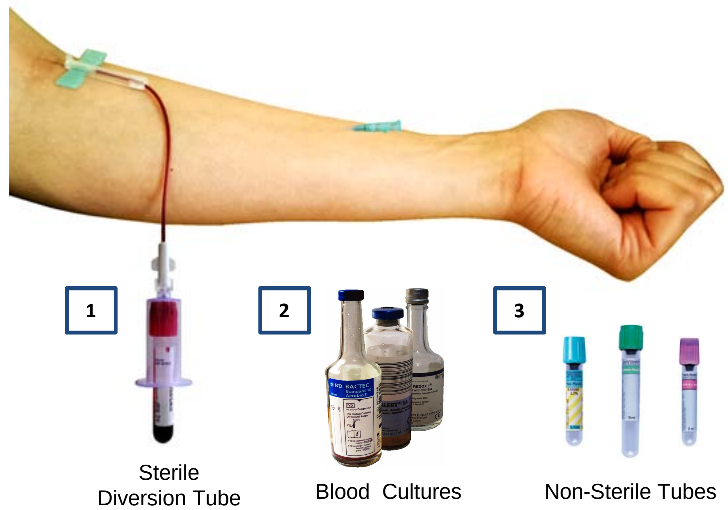
Diversion Systems and Methods

Diversion methods are capable of handling most of the sources of contamination by diverting initial blood flow before the blood culture samples are drawn. Diversion methods draw contaminants into a sterile tube prior to blood cultures as shown in Figure 3.

Historically, the Clinical Laboratory Standards Institute (CLSI) has recommended that blood culture samples be drawn first in the standard order of draw. Nearly all hospitals use the CLSI standard. When blood cultures are drawn first, bacteria from re-palpation, subsurface glands, inadequate antiseptic use, and contaminated equipment can be drawn into blood cultures resulting in contamination. In 2013 CLSI revised the standard order of draw to include sterile tubes and blood cultures in the first group of samples drawn.[5] This new standard may accommodate diversion methods.

Figure 3

Order of draw for the diversion method



Diversion Method Results

The first published clinical trials on the diversion method appeared in the Journal of Clinical Microbiology in December 2010. The study reported a 2.0% rate of contamination with the diversion method and 3.8% for the standard method control, a 47% reduction.[6] The study used antiseptic treated diversion tubes to draw 1 - 2mLs of initial blood flow and established a basis for future development of the diversion method.

Clean Collect® is a diversion system that provides pre-sterilized diversion tubes sealed in a kit to ensure sterility of the exterior of the tube. When used in clinical practice, Clean Collect® has demonstrated an average contamination rate of 0.5% for 3,134 blood cultures recorded. Blood cultures drawn through IVs in emergency departments averaged 0.8% contamination for Clean Collect® compared to 6.5% for standard methods. Clean Collect® averaged 0.3% for peripheral blood cultures compared to 2.2% for standard methods.[7] Table 2 provides the results of using Clean Collect® in clinical practice at emergency departments and hospital floors.

Table 2 – Contamination Results from a Diversion System

Start Date	Department(s)	Usage	Previous Average	Clean Collect	Contaminants	Blood Cultures	IV Drawn	Peripheral
1 - (3/01/13)	ED and floors	~90%	3.8%	0.0%	0	111	34	77
2 - (3/12/13)	Emergency	77%	4.6%	0.8%	2	240	120	120
3 - (5/01/13)	Emergency	82%	6.3%	0.7%	2	295	146	149
4 - (6/20/13)	Emergency	*	6.1%	0%	0	86	43	43
5 - (07/01/13)	Emergency	91%	4.2%	0.9%	2	212	104	108
6 - (08/01/13)	Emergency	79%	3.8%	1.0%	3	285	181	104
7 - (10/10/13)	Emergency	92%	4.5%	0.8%	2	245	133	112
8 - (1/22/14)	Emergency	*	4.0%	0%	0	220	120	100
9 - (3/21/14)	Emergency	~90%	3.5%	0.4%	1	285	128	157
10 - (4/15/14)	ED and floors	83%	3.6%	0.4%	1	281	0	281
11 - (4/24/14)	Emergency	85%	5.5%	0%	0	180	96	84
12 - (5/01/14)	Emergency	~85%	3.2%	0%	0	164	76	88
13 - (6/04/14)	Floors only	87%	3.5%	0%	0	122	0	122
14 - (6/04/14)	Emergency	*	4.5%	0%	0	112	75	37
15 - (7/18/14)	ED and floors	78%	4.1%	0.7%	2	296	86	210
* No data on usage rate was recorded at these sites								
Totals/Averages		84%	**4.3%**	**0.5%**	15	3134	1342	1792

Application of Diversion Methods in Clinical Practice

While conceptually the diversion method is simple, successful application in clinical practice requires sterility of the diversion tube and consistent compliance with the method.

Diversion Tube Sterility

With standard methods, blood cultures are drawn first to avoid carrying contaminants over from the stoppers of non-sterile tubes into blood cultures as described in Figure 4.

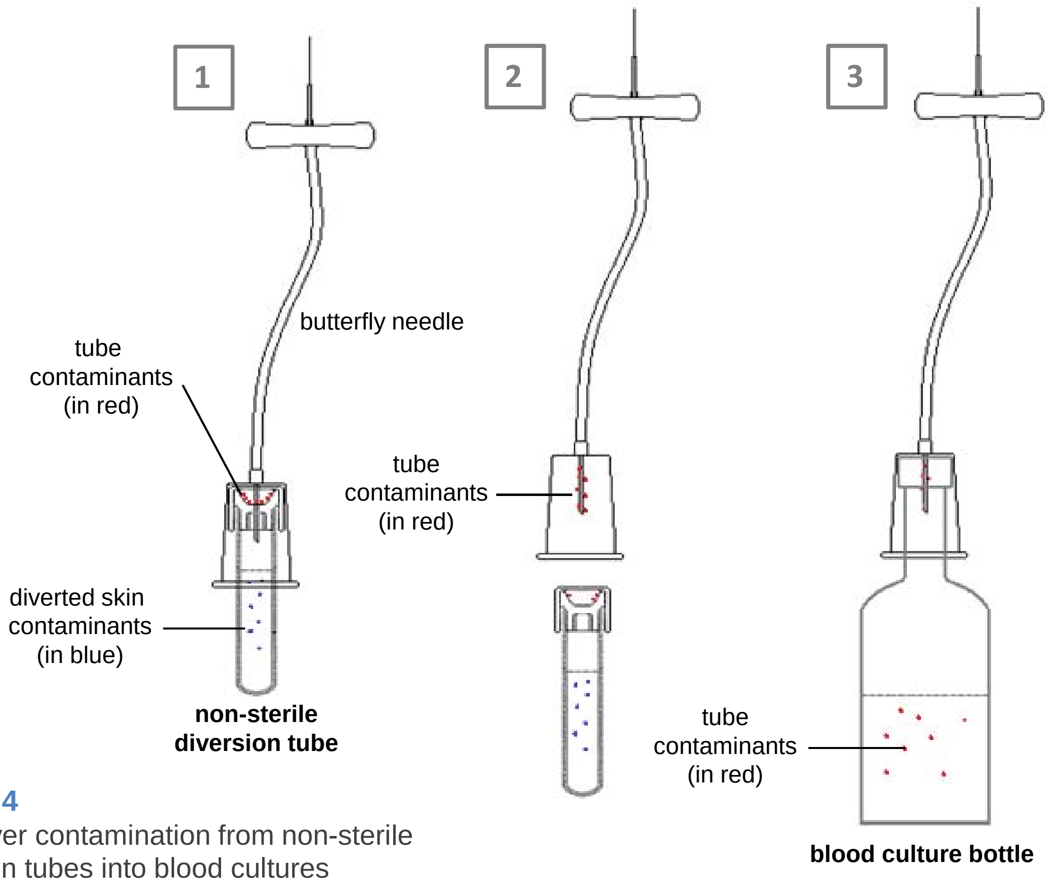


Figure 4
Carryover contamination from non-sterile diversion tubes into blood cultures

Due to carryover contamination, the use of diversion tubes that are not completely sterile on the exterior can be counterproductive, increasing the contamination rate instead of reducing it. Regular blood collection tubes used for routine blood collection are not sterile on the exterior. A lab study on the use of regular tubes for the diversion method indicated that non-sterile diversion tubes can increase the contamination rate up to 16.8%.[8]

Treating regular tubes with antiseptic is another possibility. However, the recessed stoppers on blood collection tubes are not easily accessed by antiseptics as seen in Figure 3. This design makes antiseptic treated tubes less suitable for the diversion method. Hospitals have reported increased contamination using antiseptic treated diversion tubes.[8]

The use of pre-sterilized diversion tubes provides a more effective means for implementing diversion methods in clinical practice as shown on Table 2.

Table 2 – Sterility of Diversion Tubes

Diversion Tube Type	Contamination Rate
Non-sterile Tube	16.8%
Antiseptic Treated Tube	4.6%
Pre-sterilized Diversion Tube	0.5%

Application of Diversion Methods in Clinical Practice (continued)

Compliance

The diversion method differs from standard blood culture collection procedures used in previous years at most hospitals. The level of compliance has a significant impact on the degree of overall reduction in contamination rates for a hospital or emergency department. Higher levels of compliance with the diversion method correlate inversely with the overall contamination rate as shown on Table 3 below.[7]

Table 3 – Compliance with Diversion Methods

Diversion Compliance	Diversion Rate	Standard Rate	Overall Rate
84%	0.5%	3.1%	0.9%
47%	0.7%	3.5%	2.2%

Diversion Systems

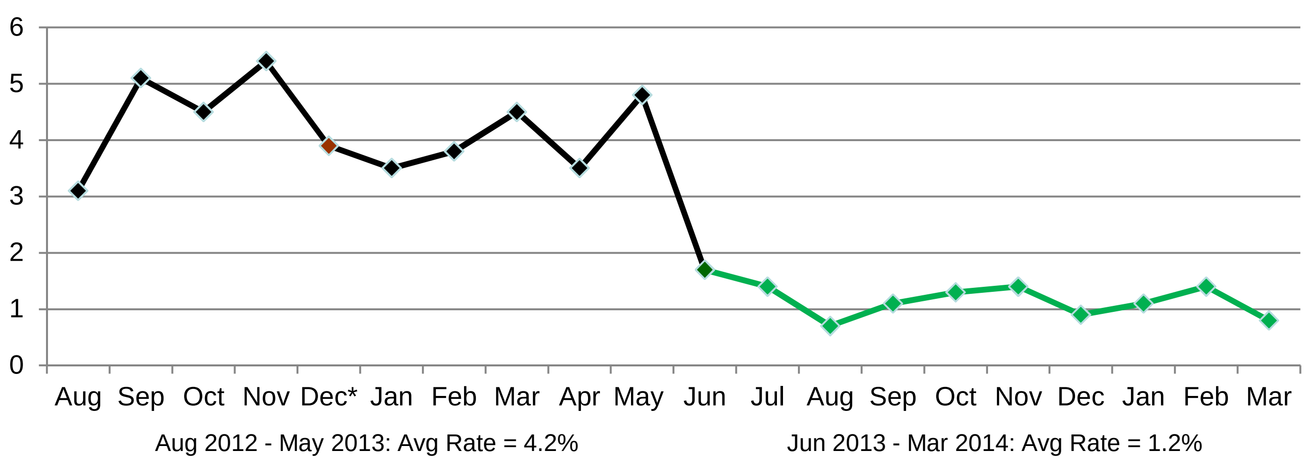
Diversion systems provide a means to ensure discard tube sterility and promote compliance with the diversion method. Clean Collect® is a diversion system based on blood culture kits that include a pre-sterilized diversion tube and materials for both peripheral and IV drawn blood cultures. The pre-sterilized diversion tube reduces the possibility of carryover contamination considerably while the complete kit allows for a greater degree of control over the collection process. Table 4 describes the differences between diversion systems and methods.

Table 4 – Comparison of Diversion Systems and Methods

	Diversion System	Diversion Method
Consistency	More consistent collection procedure with higher compliance	Less consistent implementation in clinical practice
Carryover Contamination	Very low probability with pre-sterilized diversion tubes	Higher probability of carryover from non-sterile diversion tubes
Performance	Average contamination rate of 0.5% seen in clinical practice	Average contamination rate of 4.6% seen in clinical practice

A diversion system is capable of achieving long term reduction in contamination with consistent execution of the diversion method.[7] Results from nine months of Clean Collect® use are shown in Figure 5.

Figure 5 – Long Term Results with a Diversion System



Impact of Reducing Blood Culture Contamination Rates

Blood culture contamination results in treatment of patients with broad spectrum antibiotics in the majority of cases.[1] Treatment with broad spectrum antibiotics results in a variety of secondary conditions including *Clostridium difficile* infection, antibiotic-associated diarrhea, pseudomembranous colitis, renal failure, liver failure, and anapyhlactic shock.

The financial cost of contamination has been measured in a number of clinical trials with the average increase in patient charges totaling $9,377 per incident. The added charges were tracked from lab, pharmacy, and cost of care on the floor.[9-12] The average cost per incident of contamination in hospital resources was estimated at $6,283 using a charge to cost ratio of 1.5 to1. Table 5 provides a summary of the data collected on the cost of contamination from several publications.

Table 4 – Cost of Contamination

Investigator	Journal	Conclusion
Dr. Rita Gander	Journal of Clinical Mircorbiology	$9,563 per contaminant
Dr. Oren Zwang	Journal of Hospital Medicine	$10,370 per contaminant
Dr. Sever Surdulescu	Clinical Perf. Quality Healthcare	$9,146 per contaminant
Dr. David Bates	JAMA	$7,670 per contaminant
Dr. William Dunagan	American Journal of Medicine	$10,240 per contaminant
	Average (in charges)	$9,377 per contaminant
	Average (resource costs)	**$6,283** per contaminant

Medicare reimbursement for most acute care hospitals is based on a Diagnosis Related Group (DRG) system. DRG systems were designed, in part, to eliminate payments for care of hospital acquired conditions (HACs).[13] In the case of blood culture contamination, unnecessary treatment results in a variety of HACs and resources used for the treatment and handling of the HAC are generally not reimbursed. At $6,283 per incident, this represents a significant loss of resources that can total several million dollars annually. Long term reduction of contamination rates can prevent the loss.

Medicare Quality Improvement Programs

In October 2016, the Center for Medicare and Medicaid Services (CMS) will begin recording *C. difficile* infection rates for the HAC Reduction Program and Value Based Purchasing (VBP) Programs. Hospitals with higher HAC scores are penalized 1% of their reimbursement for all DRGs.[14] Hospitals with low scores in the VBP program can lose up to 2% of their reimbursement.[15] These penalties can be significant, totaling several million dollars annually for penalized hospitals.

Conclusion

The substantial cost and consequences of blood culture contamination for both patients and hospitals warrants an effort to minimize the frequency of the problem. Diversion systems are capable of controlling contamination for prolonged periods even in emergency departments where rates often persist at the highest levels. Long term control of blood culture contamination can provide significant benefit to hospitals and their patients.

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