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Innovation for Reducing Blood Culture Contamination: Initial Specimen Diversion Technique[▽]

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We hypothesized that diversion of the first milliliter of venipuncture blood—the initial specimen diversion technique (ISDT)—would eliminate incompletely sterilized fragments of skin from the culture specimen and significantly reduce our blood culture contamination rate (*R*). We studied our hypothesis prospectively beginning with our control culture (C) definition: one venipuncture with two sequentially obtained specimens, 10 ml each, the first specimen (M1) for aerobic and the second (M2) for anaerobic media. The test ISDT culture (D) was identical, with the exception that each was preceded by diverting a 1-ml sample (D_S) from the same venipuncture. During the first of two sequential 9-month periods, we captured D versus C data (n = 3,733), where $D_{MX}R$ and $C_{MX}R$ are *R* for D and C specimens. Our hypothesis predicted D_S would divert soiled skin fragments from D_{M1}, and therefore, $C_{M1}R$ would be significantly greater than $D_{M1}R$. This was confirmed by $C_{M1}R$ (30/1,061 [2.8%]) less $D_{M1}R$ (37/2,672 [1.4%]; P = 0.005), which equals 1.4%. For the second 9-month follow-up period, data were compiled for all cultures (n = 4,143), where $AD_{MX}R$ is *R* for all (A) diversion specimens, enabling comparison to test ISDT. Our hypothesis predicted no significant differences for test ISDT versus all ISDT. This was confirmed by $D_{M\ 1}R$ (37/2,672 [1.4%]) versus $AD_{M\ 1}R$ (42/4,143 [1.0%]; P = 0.17) and $D_{M2}R$ (21/2,672 [0.80%]) versus $AD_{M2}R$ (39/4,143 [0.94%]; P = 0.50). We conclude that our hypothesis is valid: venipuncture needles soil blood culture specimens with unsterilized skin fragments and increase *R*, and ISDT significantly reduces *R* from venipuncture-obtained blood culture specimens.

As a clinical laboratory test, blood culture has played a major diagnostic role in medicine for decades. One limitation of this diagnostic role is false-positive results, which increase expenses and have an adverse patient safety impact (1, 2). Consequently, numerous interventions with blood culture processes have been employed by laboratories to reduce contamination (5, 6). The purpose of this report is to introduce a new blood culture technique that significantly reduced the blood culture contamination rate (*R*) in this study. This innovation, the initial specimen diversion technique (ISDT), omits the first approximately 1-ml portion of venipuncture blood from the culture specimen without compromising or diminishing the volume of blood optimum for culture. The basis for ISDT is the hypothesis that skin fragments incompletely sterilized by skin surface antisepsis and dislodged by venipuncture increase *R*. We evaluated our hypothesis prospectively first with test ISDT versus control cultures for a 9-month period (group 1; n = 3,733 cultures). Next, we collected data for a second 9-month period with an all-cultures ISDT (group 2; n = 4,143) for comparison to test ISDT.

MATERIALS AND METHODS

Patients and phlebotomists. The blood cultures in this study were from adults suspected of having sepsis who were hospitalized, evaluated in the emergency room, or seen as outpatients in a not-for-profit urban community hospital setting. Venipunctures (peripheral vein sites only) were performed by laboratory-trained and supervised phlebotomists who wore safety gloves during the procedure. No indwelling-catheter-obtained specimens were included in this study. Our standard procedure of monitoring needle puncture and other laboratory staff issues was continued during and after the study.

Skin preparation. Prior to venipuncture, the skin antisepsis agent 2% chlorhexidine-70% alcohol (Medi-Flex Hospital Products, Inc., Overland Park, KS) was applied with a sponge using vertical and horizontal strokes in a washboard manner for 30 s over a 5- by 5-cm area. The scrubbed area was allowed to dry and was not repalpated prior to venipuncture.

Blood culture definition and initial specimen diversion technique. A blood culture was defined as two separate 10-ml specimens obtained serially from one venipuncture for sequential inoculation of bottled media, M1 (aerobic) and M2 (anaerobic). Medium bottle stoppers were cleaned with a 70% isopropyl alcohol wipe, which was left in place prior to inoculation. The culture medium bottles were incubated in an automated computer-monitored system (BacT/Alert SN Microbial Detection System; bioMérieux S.A, Durham, NC) and in the event of growth were Gram stained and subcultured for identification. We used a push-button blood collection apparatus (Becton Dickinson and Company, Franklin Lakes, NJ) with a 21-gauge venipuncture needle for blood culture specimen collection and inoculation (Fig. 1). The apparatus included a venipuncture needle (1), wings (2) to aid insertion of the venipuncture needle, tubing (3) for blood transfer, and a protective adapter (4) that facilitated medium bottle inoculation. Inoculation was enabled within the adapter by a second needle (Fig. 1, inset). The venipuncture and inoculation needles had safety covers. The inoculation needle cover was rubberized and re-covered the needle between medium inoculations. Blood culture specimens (10 ml each) were collected sequentially directly to M1 and then to M2 (Fig. 2). The medium bottle volume in 5-ml increments was shown on the medium bottles, providing precision in measuring the culture specimen volume. The medium bottles were held vertically, and the desired 10-ml increment was marked with a pen or the phlebotomist's thumb nail. The procedure was the same for ISDT blood culture (D), with the exception that each was preceded by diverting the first milliliter (D_S) of the same venipuncture blood into a 3-ml sterile Vacutainer collection tube (Becton Dickinson and Company, Franklin Lakes, NJ) (Fig. 1). For patients with small veins, syringes and 23-gauge needles were used for blood collection as follows. The collection needle/adapter attachment apparatus (Fig. 1, inset, 5) was removed, enabling a syringe connector (6) to be attached. Syringes (3 ml and 10 ml) collected the 1-ml D_S and culture samples, respectively. A separate safety needle was attached to the 10-ml syringes for transferring culture specimens to medium

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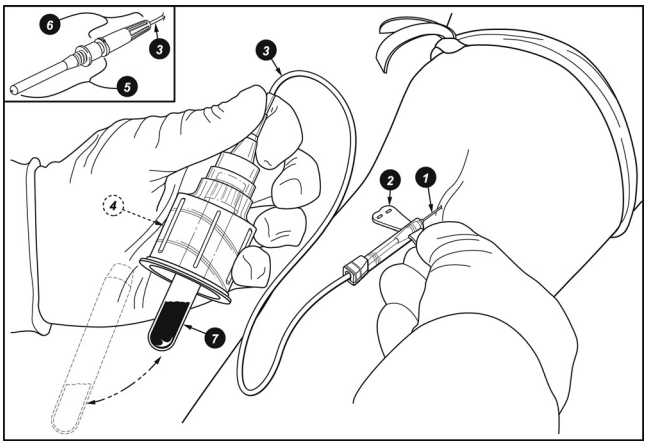

FIG. 1. ISDT diversion step prior to culture. 1, venipuncture needle; 2, wings to aid insertion of the venipuncture needle; 3, tubing for blood transfer; 4, protective adapter to facilitate medium bottle inoculation; 5, collection needle/adapter attachment apparatus; 6, syringe connector; 7, diversion tube. (Inset) Diversion inoculation needle detail.

containers. The medium bottles were placed in racks for the syringe/safety needle inoculation; hand-held medium inoculation was not permitted.

Blood cultures were classified as false positive if one or more of the following organisms were isolated from only one of a series of blood culture specimens: coagulase-negative *Staphylococcus* spp., *Propionibacterium acnes*, *Micrococcus* spp., "viridans" group streptococci, *Corynebacterium* spp., or *Bacillus* spp. (2).

Data groups. For the first of two 9-month periods, June 2007 through February 2008, culture specimen collection was tracked for test ISDT versus C (group 1). Training for ISDT commenced prior to and continued at the beginning of the period, followed by randomization of test-ISDT versus C. Before randomization was fully implemented, significant reduction of R by ISDT became obvious; therefore, in the best interest of our patients and our institution, randomization was discontinued and all cultures were obtained with ISDT. For a second 9-month period, April through December 2008, blood culture specimens were obtained with all ISDT (group 2). Confirmation of receipt in the laboratory and the blood volume of D_S were also tracked. D_S was not cultured.

Statistical method. Pearson's chi-square test was used to evaluate the significance of the blood culture groups compared; significance was defined as a P value of ≤ 0.05.

RESULTS

During the first of two sequential 9-month periods, we captured test ISDT data, D versus C data (n = 3,733), which can be expressed as

$$D_T R = D_S R + D_{M1} R + D_{M2} R \quad (1)$$

and

$$C_T R = C_{M1} R + C_{M2} R \quad (2)$$

where $D_{MX}R$, $C_{MX}R$, and $D_S R$ are R for D, C, and D_S specimens and $D_T R$ and $C_T R$ are total R for D and C. Our ISDT hypothesis predicted that D_S would divert soiled skin fragments from D_{M1}, and therefore, $C_{M1}R$ would be significantly greater than $D_{M1}R$. This was confirmed by $C_{M1}R$ (30/1,061 [2.8%]) less $D_{M1}R$ (37/2,672 [1.4%]; P = 0.005) equaling 1.4%. Also predicted was that ISDT would show no significant difference between $C_{M2}R$ and $D_{M2}R$. Confirmation came as $C_{M2}R$ (11/1,061 [1.0%]) less $D_{M2}R$ (21/2,672 [0.8%]; P = 0.31) equaling 0.2%. Additionally, we assumed $D_T R$ was equal to $C_T R$, and therefore,

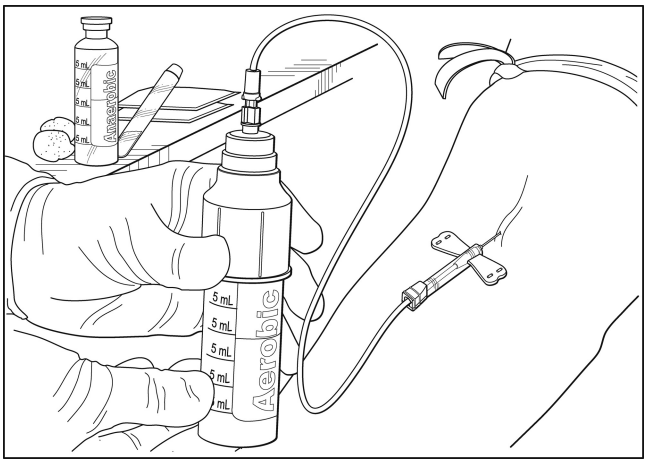

FIG. 2. ISDT direct-to-medium inoculation step.

$$D_S R = C_{M1} R + C_{M2} R - D_{M1} R - D_{M2} R \quad (3)$$

Thus, $D_S R$ was discrete, could be calculated, and was 1.6%. Regarding the second 9-month follow-up period for comparison to test ISDT, ISDT data were compiled for all (A), $AD_T R$, and $AD_{MX}R$, cultures (n = 4,143),

$$AD_T R = AD_{M1} R + AD_{M2} R \quad (4)$$

Our hypothesis predicted no significant differences for test ISDT versus all ISDT. This was confirmed by $D_{M\ 1}R$ (37/2,672 [1.4%]) versus $AD_{M\ 1}R$ (42/4,143 [1.0%]; P = 0.17) and $D_{M2}R$ (21/2,672 [0.80%]) versus $AD_{M2}R$ (39/4,143 [0.94%]; P = 0.50). The data are shown in Table 1 for all cultured specimens, as are comparison contamination rates for control versus test ISDT and all ISDT versus test ISDT. The only significant comparison difference was test ISDT M_1 versus control M_1 (1.4%). This difference can be attributed to the diversion of unsterilized skin fragments from control M_1 by ISDT (formulas 1 and 2), and this difference in the study can be quantified (formula 3) as 1.6%. The lack of significant differences between test ISDT M_1 and M_2 and AD M_1 and M_2 rates are consistent with our hypothesis: ISDT significantly reduces contamination in venipuncture-obtained blood culture specimens.

For one randomly chosen month (February 2008), the diversion volume distribution was 152 (40%) >0.5 ml and ≤1.0 ml, 256 (68%) ≤1.5 ml, 351 (93%) ≤2.0 ml, and ≤3.0 ml (100%) (n = 376).We conclude that ≥0.5 ml and ≤2.0 ml is adequate diversion volume to significantly reduce contamination.

The clinical service distribution of blood cultures during the study was inpatients 77.2%, emergency department 15.9%, and outpatients 6.9% (n = 11,330). None of these were ≤16 years of age.

Phlebotomists did not suffer needle sticks or other injuries as a result of this study.

DISCUSSION

Every pathologist who has examined numerous needle aspirations of bone marrow and other viscera has observed skin fragments (mini-biopsy specimens) contaminating these aspiration specimens. Based on this experience, we sought

TABLE 1. Comparison of *R* for control versus test ISDT and all ISDT versus test ISDT culture groups

Group	Total no. of blood cultures	M1 (aerobic) cultures			M2 (anaerobic) cultures		
		% (No.) false positive	Difference (%)	*P* value	% (No.) false positive	Difference (%)	*P* value
1st 9 mo							
Control	1,061	2.8 (30)	1.4	0.005	1.0 (11)	0.2	0.31
Test ISDT	2,672	1.4 (37)			0.8 (21)		
2nd 9 mo							
All ISDT	4,143	1.0 (42)	0.4[a]	0.17	0.9 (39)	−0.1	0.50

[a] Test ISDT rate from first 9 months less all ISDT rate from second 9 months used for comparison.

improvement in our blood culture contamination rate. We hypothesized that small fragments of skin dislodged by a venipuncture needle harbor bacteria not killed by skin surface antisepsis and that they are a discrete cause of contamination. Additionally, we hypothesized that diverting the first milliliter of venipuncture blood and subsequently obtaining a culture specimen from the same venipuncture would eliminate some of these fragments from the culture specimen and significantly reduce contamination and that it would do so without compromising blood culture sensitivity. We refer to this diversion method as ISDT.

Our results show that ISDT significantly reduces contamination of blood cultures by excluding contaminants from the first portion of venipuncture-obtained culture specimens. Given this, several questions arise. What other studies have been done that may corroborate our findings? What is the optimum volume of blood for diversion? What is the cost of ISDT, and are there laboratory worker safety issues? Finally, do we recommend ISDT to other laboratories?

Regarding other studies, to our knowledge, reduction of contamination by diversion has not been previously studied in detail or quantified for venipuncture-obtained blood culture specimens. In contrast, diversion has been extensively studied and quantified for donor blood components. Diversion of the first part of donor blood to reduce the risk of bacterial contamination in recipients is a worldwide standard. Diversion volumes ranging from 10 to 50 ml are credited with having reduced contamination of blood components by 40 to 90% between 1995 and 2007 (7). Similar reductions in contamination of blood cultures may be realized with less diversion volume, as a blood culture needle is commonly a smaller gauge than a donor needle. The usual 16-gauge donor needle (bore, 1.19 mm) captures numerous plugs of skin contaminants (3). One would expect less contamination from our 21-gauge culture needle (bore, 0.514 mm), which has a cross-sectional area less than 1/5 that of the donor needle.

As for the optimum diversion volume for blood cultures, this study showed significant improvement in contamination with a volume of ≥0.5 ml and ≤2 ml. More diversion volume is likely better. Our data show that all specimens subsequent to ≥2.0 ml of diversion (C_{M2}, D_{M1}, D_{M2}, AD_{M1}, and AD_{M2}) had an average *R* of 1%. Hence, 20 ml of diversion would very likely decrease contamination further. However, with meticulous oversight, increased experience with diversion, and both initial and remedial training using a video of our diversion technique, our phlebotomists have achieved an *R* of <1% in the first 6 months of 2010, an *R* which a short time ago we would have thought impossible. We are satisfied with our current diversion volume but are considering increasing the volume to 3 or possibly 5 ml. Another improvement tactic is drawing blood for other tests (blood counts, chemistry, etc.) prior to blood culture.

ISDT can be cost-effective by lowering patient care charges. Recently, in a large emergency department (ED), patient charges were increased by $8,720 for each contaminated blood culture (4). If our IDST procedure were implemented in this ED, with 5,432 blood cultures in 13 months, annual charges would decrease by $699,575 for an increase in supply costs of $3,510. Our costs for ISDT supplies are minimal (blood collection apparatus, $1.28, and diversion tube, $0.07), replacing a theoretical 20-ml syringe and two safety needles ($0.65). Reduced contamination is based on our calculated $D_S R$ of 1.6%, and these cost savings can accrue without employee safety issues. We had no needle sticks or other injuries to our phlebotomists or other laboratory workers during this study.

For venipuncture-obtained specimens, we believe ISDT significantly reduces blood culture contamination, has a high benefit/cost ratio, is practical and safe for laboratory personnel and patients, and does not compromise blood culture sensitivity. We recommend ISDT to other laboratories.

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REFERENCES

1. **Bates, D. W., L. Goldman, and T. H. Lee.** 1991. Contaminant blood cultures and resource utilization; the true consequences of false-positive results. JAMA **265:**365–369.
2. **Bekeris, L. G., J. A. Tworek, M. K. Walsh, and P. N. Valenstein.** 2005. Trends in blood culture contamination: a College of American Pathologists Q.-Tracks study of 356 institutions. Arch. Pathol. Lab. Med. **129:**1222–1225.
3. **Buchta, C., N. Nedorost, H. Regele, M. Egerbacher, G. Körmöczi, P. Höcker, and M. Dettke.** 2005. Skin plugs in phlebotomy puncture for blood donation. Wien Klin. Wochenschr. **117:**141–144.
4. **Gander, R. M., L. Byrd, M. DeCrescenzo, S. Hirany, M. Bowen, and J. Baughman.** 2009. Impact of blood cultures drawn by phlebotomy on contamination rates and health care costs in a hospital emergency department. J. Clin. Microbiol. **47:**1021–1024.
5. **Hall, K. K., and J. A. Lyman.** 2006. Updated review of blood culture contamination. Clin. Microbiol. Rev. **19:**788–802.
6. **Little, J. R., P. R. Murray, P. S. Traynor, and E. Spitznagel.** 1999. A randomized trial of providone-iodine compared with iodine tincture for venipuncture site disinfection: effects on rates of blood culture contamination. Amer. J. Med. **107:**119–125.
7. **Liumbruno, G. M., L. Castalano, V. Piccinini, S. Pupella, and G. Grazzini.** 2009. Reduction of the risk of bacterial contamination of blood components through diversion of the first part of the donation of blood and blood components. Blood Transfus. **7:**86–93.