An Innovation for Reducing Blood Culture Contamination: Initial Specimen Diversion Technique

Reducing Blood Culture Contamination: Diversion

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ABSTRACT:

We hypothesized diversion of the first mL of venipuncture blood, 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 each was preceded by diverting a 1 mL sample (D₁) from the same venipuncture. During the first of two sequential 9 month periods, we captured D versus (v) C data (n=3,733) where Dₘ₁R and Cₘ₁R are R for D and C specimens. Our hypothesis predicted D₈ would divert soiled skin fragments from Dₘ₁ and therefore, Cₘ₁R would be significantly greater than Dₘ₁R. This was confirmed by Cₘ₁R (30/1,061 [2.8%]) less Dₘ₁R (37/2,672 [1.4%]; P = 0.005) equals 1.4%.

Regarding the second 9-month follow up period, data were compiled for all cultures (n=4,143) where Aₘ₁R are R for all (A) diversion specimens enabling comparison to test-ISDT. Our hypothesis predicted no significant differences for test-ISDT v all-ISDT. This was confirmed; Dₘ₁R (37/2,672 [1.4%]) v Aₘ₁R (42/4,143 [1.0%]; P = 0.17), and Dₘ₂R (21/2,672 [0.80%]) v Aₘ₂R (39/4,143 [0.94%]; P = 0.50). We conclude 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.

INTRODUCTION:
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 of blood culture processes have been employed by laboratories to abate contamination (5). The purpose of this report is to introduce a new blood culture technique which significantly reduced the blood culture contamination rate (R) in this study. This innovation, initial specimen diversion technique (ISDT), omits the 1st 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 (v) control cultures for a 9 month period (group 1, n=3,733 cultures). Next, we collected data for a 2nd nine month period with all cultures ISDT (group 2, n=4,143) for comparison to test-ISDT.

MATERIALS & METHODS:

Patients and phlebotomists. Blood cultures in this study were from adults suspected of having sepsis who were hospitalized, evaluated in the emergency room, or seen as out-patients 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 this study.
Skin preparation. Prior to venipuncture the skin antisepsis agent, 2% chlorhexidine 70% alcohol (Medi-Flex Hospital Products, Inc., Overland Park, Kansas) was applied with a sponge using vertical and horizontal strokes in a washboard manner for 30 seconds over a 5 X 5 cm area. The scrubbed area was allowed to dry and was not re-palpated 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). Media bottle stoppers were cleaned with a 70% isopropyl alcohol wipe which was left in place prior to inoculation. Culture media bottles were incubated in an automated computer monitored system (BacT/ALERT SN Microbial Detection System, bioMérieux S.A, Durham, North Carolina), and in the event of growth were gram stained and subcultured for identification. We used a pushbutton blood collection apparatus (Beckton, Dickinson and Company, Franklin Lakes, NJ) with a 21-gauge venipuncture needle for blood culture specimen collection and inoculation (see Illustration 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) which facilitated media bottle inoculation. Inoculation was enabled within the adapter by a second needle (see Inset, Illustration 1). The venipuncture and inoculation needles had safety covers. The inoculation needle cover was rubberized and re-covered the needle between media inoculations. Blood culture specimens (10 mL each) were collected sequentially direct to M1 and then M2 (see Illustration 2). Media bottle volume in 5 mL increments was shown on the media bottles providing precision in measuring culture
specimen volume. Media 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 1st mL (Dₛ) of the same venipuncture blood into a 3 mL sterile Vacutainer collection tube (Beckton, Dickinson and Company, Franklin Lakes, NJ), Illustration 1. For patients with small veins, syringes and 23-gauge needles were used for blood collection as follows:

The collection needle/adapter attachment apparatus (5), Illustration 1 inset, was removed thus enabling a syringe connector (6). 3 mL and 10 mL syringes collected the 1 mL Dₛ and culture samples, respectively. A separate safety needle was attached to the 10mL syringes for transferring culture specimens to media containers. Media bottles were placed in racks for the syringe/safety needle inoculation; hand held media 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 species, Propionibacterium acnes, Microoccus species, “viridans” group streptococci, Corynebacterium species, or Bacillus species (2).

Data Groups. For the first of two nine month periods, June 2007 through February 2008, culture specimen collection was tracked for test-ISDT v C (group 1). Training for ISDT commenced prior to and continued at the beginning of the period to be followed by randomization of test-ISDT v 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 2nd 9 months, April through December 2008, blood culture
specimens were obtained with all-ISDT (group 2). Confirmation of receipt in the
laboratory and blood volume of D_S were also tracked. D_S was not cultured.

**Statistical method.** Pearson’s Chi square test was used to evaluate significance of
compared blood culture groups, significance being defined as P<= .05.

**RESULTS:**
During the first of two sequential 9 month periods, we captured test-ISDT data, D
versus (v) C data (n=3,733) which can be expressed as
\[
(F1) \quad D_T R = D_S R + D_M1 R + D_M2 R
\]
and
\[
(F2) \quad C_T R = C_M1 R + C_M2 R
\]
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 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) equals
1.4%. Also predicted was ISDT showing 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) equals 0.2%. Additionally, we assume D_T R = C_T R, and therefore
\[
(F3) \quad D_S R = C_M1 R + C_M2 R - D_M1 R - D_M2 R.
\]
Thus, D_S R is 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),
\[
(F4) \quad AD_T R = AD_M1 R + AD_M2 R.
\]
Our hypothesis predicted no significant differences for test-ISDT v all-ISDT. This was confirmed; $D_{M1}R$ (37/2,672 [1.4%]) v $A_{M1}R$ (42/4,143 [1.0%]; $P = 0.17$), and $D_{M2}R$ (21/2,672 [0.80%]) v $A_{M2}R$ (39/4,143 [0.94%]; $P = 0.50$). Data are shown in Table 1 for all cultured specimens as are comparison contamination rates for control v test-ISDT and all-ISDT v test-ISDT. The only significant comparison difference is test-ISDT $M_1$ v control $M_1$, 1.4%. This difference can be attributed to the diversion of unsterilized skin fragments from control $M_1$ by ISDT. See formulas (F1) and (F2). And this difference in this study can be quantified (F3), 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) diversion volume distribution was 152 (40%) > 0.5mL and ≤ 1.0mL, 256 (68%) ≤ 1.5mL, 351 (93%) ≤ 2.0mL, and ≤ 3.0 mL (100%), n=376. We conclude, > 0.5mL and ≤ 2.0mL 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 stick 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-biopsies) contaminating these aspiration specimens. Based on this experience and seeking improvement in our blood culture
contamination rate, we hypothesized small fragments of skin dislodged by a venipuncture needle harbor bacteria not sterilized by skin surface antisepsis, and are a discrete cause of contamination. Additionally, we hypothesized diversion of the first mL of venipuncture blood and subsequently obtaining a culture specimen from the same venipuncture would eliminate some of these fragments from the culture specimen, significantly reduce contamination, and do so without comprising blood culture sensitivity. We refer to this diversion method as ISDT.

Results show 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 which 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? And, do we recommend ISDT to other laboratories?

Regarding other studies, to our knowledge diversion reduction of contamination 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 risk of bacterial contamination in recipients is a world-wide 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 donor needle, 16 gauge (bore 1.19 mm), captures numerous plugs of skin contaminants (3). One would expect less contamination
from our culture needle, 21 gauge (bore 0.514 mm), which has a cross sectional area less than 1/5th of the donor needle.

Regarding optimum diversion volume for blood cultures, this study showed significant improvement in contamination with a volume \( \geq 0.5 \text{mL} \) and \( \leq 2 \text{mL} \). More diversion volume is likely better. Our data show all specimens subsequent to \( \geq 2.0 \text{mL} \) of diversion \( (C_{M2}, D_{M1}, D_{M2}, AD_{M1}, \text{and } AD_{M2}) \) had an average R of 1%. Hence, 20 mL of diversion would very likely decrease contamination further. But, 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). Were our IDST procedure 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 + diversion tube $0.07) replacing a theoretical 20 mL syringe and two safety needles ($0.65). Reduced contamination is per our calculated \( D_s R \) of 1.6%. And these cost savings can accrue without employee safety issues. We had no needle stick 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.

ACKNOWLEDGEMENTS:

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REFERENCES:


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<tr>
<th>Group</th>
<th>Test n=IDST</th>
<th>Control n=IDST</th>
<th>( \Delta ) n=IDST</th>
<th>Positive/RAE (±SD)</th>
<th>Positive RA (%)</th>
<th>( p ) Value</th>
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<tbody>
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<td>M1 (Amarillo) Cultures</td>
<td>0.31</td>
<td>0.005</td>
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<td>1.0% (2.7)</td>
<td>1.4%</td>
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<tr>
<td>M2 (Amarillo) Cultures</td>
<td>0.4% (3.7)</td>
<td>1.4%</td>
<td>1.0% (1.1)</td>
<td>2.6% (3.9)</td>
<td>1.061</td>
<td>0.005</td>
</tr>
<tr>
<td>Total no. of blood cultures</td>
<td>2.6%</td>
<td>1.061</td>
<td>2.6%</td>
<td>1.0% (1.1)</td>
<td>2.6% (3.9)</td>
<td>0.005</td>
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</tbody>
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**Table 1.** Comparison of contamination rates (R) for Control vs. Test-IDST and All-IDST vs. Test-IDST culture groups.