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Research Article

Impact of Blood Cultures Drawn by Phlebotomy on Contamination Rates and Health Care Costs in the ICU ward of a Tertiary Hospital

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ABSTRACT

Blood culture contamination represents an ongoing source of frustration for clinicians and microbiologists alike. Ambiguous culture results often lead to diagnostic uncertainty in clinical management and are associated with increased health care costs due to unnecessary treatment and testing. A variety of strategies have been investigated and employed to decrease contamination rates. In addition, numerous approaches to increase our ability to distinguish between clinically significant bacteraemia and contamination have been explored. In our study the contamination rates of blood cultures drawn by phlebotomy in the ICU ward was determined and the impact of false positive blood culture tests on health care costs of patients due to extended lengths of stay and unnecessary treatment with drugs was also determined. Later after training the nurses in the ICU and by using the disinfectant with appropriate contact time, the contamination rates came down to 5.3% (though the guidelines say 2-3% as the accepted contamination rates allowed). Since it was a pilot study, intervention was done only in the ICU. Probably the same can be tried by appointing a phlebotomist and it can be practised in all wards; then surely contamination rates will come down to less than 3%. By maintaining vigilance with preparation, by appropriate utilization of equipment, sampling techniques and by giving feed back to the staff concerned regarding contamination rates, it is possible to make the move towards zero false positives.

Keywords: Blood culture, Bacteraemia.

1. INTRODUCTION:

Blood culture is the most important microbiological test in the diagnosis of serious infection especially for detecting bacteraemia in patients and venepuncture is the most routinely performed invasive technique to obtain blood for blood culture tests. Like any other test, however, false-positive blood culture results can limit the utility of this important tool.

Contamination with insignificant skin flora organisms, however, occurs in up to 10 % of blood cultures taken and is associated with substantial healthcare costs. Positive blood cultures, regardless of the source of the infection, require clinicians to act quickly. While a positive blood culture should always be considered significant until proven otherwise, some positive cultures will be due to contamination especially if adequate skin preparation is not employed. Doctors must therefore decide if the culture results are consistent with the patient's condition and clinical symptoms or if the results reflect possible contamination. False-positive blood cultures arise due to contamination that occurs when organisms that are not actually present in a blood sample are grown in culture.[1]

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Preventing blood culture contamination is important in order to reduce undesirable clinical outcomes including the inappropriate use of antibiotics, additional laboratory testing and associated costs such as longer hospital stays, laboratory and pharmacy expenditure[2]. Inappropriate use of antibiotics can potentiate the emergence of multi-drug resistant organisms. Best practice guidance states that blood cultures should only be collected by members of staffs who have been trained in the procedure and whose competence in blood culture collection has been assessed[3]. Reduction in blood-culture contamination rates of up to 50 % have been demonstrated using individual feedback mechanisms.

So we planned to do a prospective study in our teaching hospital, to determine whether the addition of phlebotomists or trained technicians in the hospital especially for ICU's will significantly lower blood culture contamination rates. The financial impact of false-positive blood cultures was also analyzed by comparing incremental charge differences and lengths of stay (LOS) between patients with false-positive, negative, and true-positive blood cultures. The importance of taking two samples for each patient (instead of one) for blood cultures would also be emphasized through this study.

2. AIMS AND OBJECTIVES

1. To determine the contamination rates of blood cultures drawn by phlebotomy in the ICU ward of a tertiary teaching hospital.
2. To calculate the impact of false positive blood culture tests on health care costs of patients due to extended lengths of stay and unnecessary treatment with drugs.
3. To reduce the contamination rates by using trained technicians/phlebotomist, the correct disinfectant with appropriate contact time and other precautions.

3. MATERIALS AND METHODS

3.1. Type of study : Prospective study.

3.3. Study Population : All patients who are 18 years of age and above admitted in the ICU ward of PSG Hospitals.

3.3 Inclusion Criteria: Any patient in the ICU ward (18 years of age or above) whose blood is drawn by phlebotomy for blood culture tests.

3.4. Exclusion Criteria:

1) Patients below the age of 18 years (in the ICU ward).

2) Unconscious patients in ICU ward.

3.5. Study Locale (geographic area): In and around Coimbatore.

3.6. Duration of the study (in months): 4 months.

Ethical clearance from the IHEC and DCRB of our institute has been obtained for the proposed study.

All consecutive samples that meet the inclusion exclusion criteria from ICU requesting blood cultures were considered.

The study (conducted in the ICU) was divided into two phases of duration two months each. During the first phase the nursing staff/ lab technicians were allowed to draw blood samples from patients by phlebotomy for the purpose of blood culture tests. The number of false positive tests, contamination rates, extended lengths of stays and increased health care costs were calculated. In the next phase the nursing staff/ lab technicians were trained in the practice of phlebotomy taking into consideration proper precautions and also feedback about the contamination rates was given to them. Once this had been done they were allowed to draw blood samples from patients.

In the first phase, routine blood cultures sent from the ICU was monitored for a period of one month. The clinical history including the antibiotic the patient is on etc was taken. On positive beeps of Bactec blood culture bottles, sub cultures were done on blood agar, chocolate agar and macconkey agar, the organisms were identified; the antibiotic sensitivity testing was done and noted. In case a contaminant grew instead of the pathogen then that was also noted. The contamination rate, length of stay and the impact on the patient like the cost incurred, the antibiotics he was prescribed based on the false positive reports etc were calculated for one month.

In the second phase, the blood samples requesting blood cultures were taken according to the following protocol:

3.6. Skin antisepsis

The person taking the blood sample should wash their hands before contact with the patient. The patient's skin should be disinfected with a swab impregnated with 2 % chlorhexidine in 70 % isopropyl alcohol and must then be allowed time to air dry.

3.6. Culture bottles

The rubber stopper on each blood culture bottle is not sterile despite being covered with a cap that requires removal before use. Recommended practice is to remove the caps and clean the tops of the culture bottles using a 2 % chlorhexidine in 70 % isopropyl alcohol impregnated swab and allow to dry prior to inoculating the bottle.

3.7. Procedure for collection of blood

- Prepare all the required equipment.
- Identify the patient, explain the procedure, and gain verbal consent.
- Wash hands with soap and water and dry.
- Apply a disposable tourniquet (if applicable).
- Select an appropriate site for venepuncture. Clean the site using an applicator containing 2% chlorhexidine in 70% isopropyl alcohol and allow to air dry. Check expiry date of culture bottles,

remove protective caps and clean the tops with the same technique.

- Wash and dry hands again or use alcohol hand rub and apply non-sterile gloves.
  Perform venepuncture without re-palpating the intended puncture site. Use either syringe and needle technique or collect the blood straight into the culture bottles using a winged blood collection device with appropriate adapter cap. Collect enough blood so that each bottle contains 8–10 ml blood.
- Remove the tourniquet, discard sharps appropriately, and apply sterile dressing to puncture site.
- Label samples with the patient's details and the time and date of the sample without obscuring or removing the barcode.
- Remove gloves, clean hands, and arrange transport to the microbiology laboratory.
- Record the procedure in the patient's records.
  The blood culture samples are processed according to CLSI guidelines , the organism is isolated , sensitivity of each organism isolated is noted and correlation is done based on number of samples received for each patient, the clinical history and the organism isolated.

3. OBSERVATIONS AND RESULTS:

During the study, 1962 blood culture specimens were obtained. . Among the 1962 blood cultures received, 339 samples were positive for blood culture. Most common pathogen isolated from blood culture was *Escherichia coli* followed by *Salmonella typhi*, *Salmonella paratyphi A* and *Acinetobacter baumanii.*

During the pre-intervention period, 340 samples were from ICU and 80 out of 340 were positive for blood culture in the ICU and about 589 blood culture samples were sent from other wards. Among them only 100 were positive for blood culture. Out of 80 positive for blood culture in the ICU, 37 of them grew pathogenic organisms and 43 grew contaminants. In the other wards, 58 samples grew contaminants and 42 grew pathogens.

In the pre-intervention stage, out of 340 samples send from the ICU, 15 patients sent two samples (one was per cutaneous sample and other was central venous catheter line tip). Out of fifteen, 10 were no growths, one grew a contaminant and 4 of them were positive for blood culture. In the post intervention phase, Out of 18 false positive cases , 9 patients sent two samples each, and 5 showed no growth , 3 of them grew pathogens and in one patient only the percutaneous sample grew a contaminant, the cvp line did not show any growth.

Antibiotic was changed based on the sensitivity report in 19 of 43 false positive cases in the pre intervention stage. After intervention, in 9 out of 18 cases antibiotic was changed based on sensitivity report.

The overall contamination rate during the pre-intervention period was about 10.8% and in the ICU alone the rate of contamination was 12.6% and among other wards the rate of contamination was 9.8%.Intervention was done only in the ICU. The staff in the ICU was trained to take samples using aseptic precautions and allowing the correct contact time before taking those samples. They were asked not to collect samples from pre-existing peripheral cannulae or sites above any existing peripheral line. They were also asked to avoid femoral line. Skin was disinfected with swab impregnated with 2% chlorhexidine in 70% isopropyl alcohol and allowed to dry. They were asked to swab from the centre in concentric circles. The culture bottle cap was removed and the top of culture bottles was cleaned with 2% chlorhexidine in 70% isopropyl alcohol and allowed to dry prior to inoculating in the bottle. The nurses also were asked to wash and dry hands before performing the venepunture.

After intervention, the number of true positives was 44 and false positives were 18; the rate of contamination in the ICU reduced from 12.6% to 5.3 %(Table2). There was a statistically significant decrease in the rate of contamination after the intervention was done(Table 1) (p value 0.0037).The list of organisms isolated in the pre-intervention period and post intervention period is depicted in Figure 1.

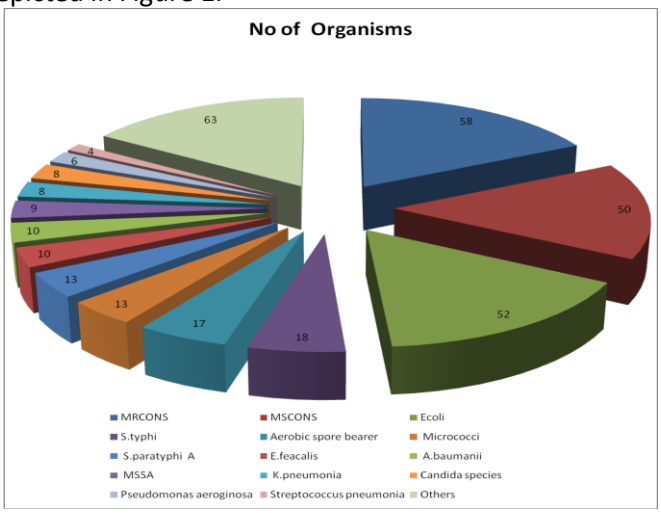

Figure 1: List of common organisms isolated from blood cultures

Blood culture in ICU	Contamination rate (%)
Before intervention	12.6%
After intervention	5.3%

Table 1: Effect of intervention on rates of contamination in the ICU

The average length of stay in the ICU for negative blood cultures was 6 days , for false positive blood culture length of stay was 7 days and for true positives the length of stay was 9 days in the ICU alone. Patients with reports of false positive blood cultures were unnecessarily made to stay longer in the ICU and antibiotics based on the blood culture report were prescribed which in turn increased the patient cost.

4. DISCUSSION:

The blood culture represents a critical tool for the health care professional as a means of detecting the dangerous presence of living organisms in the bloodstream. A positive blood culture can suggest a definitive diagnosis, enable the targeting of therapy against the specific organism(s) in question, and provide prognostic value[1]. Like any test, however, false-positive results can limit the utility of this important tool[1]. In blood cultures, false positives arise due to contamination, which occurs when organisms that are not actually present in a blood sample are grown in culture.

Contaminated cultures have been recognized as a troublesome issue for decades and continue to be a source of frustration for clinical and laboratory personnel alike. Faced with a positive blood culture result, clinicians must determine whether the organism represents a clinically significant infection associated with great risk of morbidity and mortality or a false-positive result of no clinical consequence[1]. Further complicating the issue in recent years is the increasing use of central venous catheters (CVC) and other indwelling vascular access devices. Interpretation of culture results for patients with these devices in place is particularly challenging because while these individuals are at increased risk for bacteraemia, such results may also indicate culture contamination or colonization of the line.[1] Despite its limitations, the blood culture remains the "gold standard" for the detection of bacteraemia.[1]

An accurate interpretation of culture results is critical not only from the perspective of individual patient care but also from the standpoint of hospital epidemiology and public health. The tracking and reporting of nosocomial infections and monitoring of bloodstream infection rates are both essential infection control activities that depend heavily on the accurate differentiation of contamination from true bacteraemia[1]. Making this determination reliably continues to be very challenging for clinicians, epidemiologists, and microbiologists. In recent decades, multiple approaches have been studied, advocated, and utilized for this purpose. Clues that may help to differentiate contamination from bacteraemia include identity of the organism, number of positive culture sets, number of positive bottles within a set, time for growth, quantity of growth, clinical and laboratory data, source of culture, and automated classification using information technology. Strategies to decrease blood culture contamination rates have included the use of specific disinfection materials ,educational interventions ,collection from separate venepuncture sites and the reliance on dedicated staff or a phlebotomist. There are studies where contamination rates have been reduced by using chlorhexidine gluconate instead of povidone iodine. [8,9]There are also studies where povidone iodine had been replaced with chloroprep antiseptic but that alone did not reduce contamination. [5,7]Even in our hospital change of Povidone iodine to chlorhexidine alone did not reduce contamination rates. There are also studies which state that education intervention coupled with the use of chlorhexidine antiseptic has helped to reduce contamination. [2, 7]

There are studies which suggest that certain organisms should almost always be thought to represent true bacteraemia or fungemia when isolated from a blood culture. These organisms included *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Escherichia coli* and other *Enterobacteriaceae*, *Pseudomonas aeruginosa*, and *Candida albicans* as suggested by Weinstein et al. Furthermore, Weinstein's personal observation is that the following organisms almost always represent a true infection when isolated from a blood culture: *Streptococcus pyogenes*, *Streptococcus agalactiae*, *Listeria monocytogenes*, *Neisseria meningitidis*, *Neisseria gonorrhoeae*, *Haemophilus influenzae*, members of the *Bacteroides fragilis* group, all *Candida* species, and *Cryptococcus neoformans*[1]. In our study Escherichia coli was the most common pathogen isolated *, followed by Salmonella typhi, Salmonella paratypi A, Acinetobacter baumanii , Klebsiella pneumonia , Candida sp including Candida albicans , Pseudomonas aeruginosa and Methicillin sensitive Staphylococcus aureus.*

The clinical uncertainty associated with the interpretation of ambiguous culture results is costly, as has been demonstrated in a number of studies of both adult and pediatric patients. While target rates for contamination have been set at 2 to 3%, actual rates seem to vary widely between institutions, from as little as 0.6% to over 6%[1]. In our pilot study we found that the contamination rates were even higher than this (12.6%). Standards published by American society for Microbiology states that acceptable contamination rates should not be higher than 2% to 3%.

The common contaminants grown in our blood culture included Coagulase negative staphylococci, Diphtheroids, aerobic spore bearers and other Corynebacterium species. Our study was done as a pilot study that is after intervention was for just two months and there was an overall contamination rate of about 10.8% and in the ICU

alone the contamination rate was 12.6%. In the post intervention period , with the help of trained nurses in the ICU, the contamination rates among the blood culture samples sent from the ICU was reduced to 5.3%.However the contamination rates from other wards where intervention was not done was still very high(9.6%). Since the study was conducted for just a short period, we could not do the intervention in other wards. The training of the staff in the ICU resulted in statistically significant reduction in the contamination rate to 5.3%. If a phlebotomist was appointed, it could be possible for us to reduce the overall contamination rates to acceptable levels. Though 2007 CLSI blood culture guidelines recommend two or three blood culture sets per septic episodes, in our study only 24 of the patients with positive blood cultures sent two sets of blood samples, all others sent only one set. Using phlebotomists at least in the ICU can probably ensure that multiple sets are collected from each patient. In addition collection of multiple blood cultures would aid physicians in the clinical interpretation of possible blood culture results. One proven methodology that can help differentiate blood culture contamination from true infection is the number of blood culture sets that grow organisms. The proportion of positive sets as a function of the total number of sets obtained can be a particularly useful tool. If only one of two sets grows an organism known to often cause contamination, this often represents a contaminant. For true bacteraemias, multiple blood culture sets will usually grow the same organism[1] But in our study; only 24 patients sent 2 samples each, one percutaneous and one cvp line. Probably once a phlebotomist is appointed we might be able to get 2 samples for each patient. There are studies which quote that when multiple cultures are obtained and return positive, the positive predictive value for true bacteraemia has been shown to improve.[10]

The common contaminants grown in our blood culture included Coagulase negative staphylococci. Coagulase negative staphylococci can cause blood stream infections in immunocompromised patients, so differentiation between contamination and true bacteraemia is difficult. History of the patient was taken in such cases and thus differentiated. Other contaminants grown included Diphtheroids, aerobic spore bearers and other Corynebacterium species. The contaminants isolated were similar to those isolated in other studies.[11] Despite numerous advances in blood culture methodology and systems in recent decades, some hospitals and laboratories have noted that an increasing proportion of blood culture isolates represent contamination compared with those in past years. There are several possible explanations for this unexpected observation. The newer continuously monitoring blood culture systems have improved algorithms for detecting microbial growth and may be detecting microorganisms present in low numbers that previously were missed. Moreover, several broth medium formulations such as the BACTEC Plus Resin media (Becton Dickinson, Sparks, Md.) and BacT/ALERT FN media (bioMerieux, Durham, N.C.) have been shown to have improved detection of staphylococci, including CoNS which most often are contaminants[12]. Thus, the ability of new systems and media to detect these organisms, even when present in small numbers, may be responsible in part for the observed increase in the proportion of blood cultures with contaminants.[12]

The financial impact of blood culture contamination has been described in a number of studies. Bates et al. found that contaminant results, compared with true-negative results, were independently associated with increased subsequent laboratory charges (20% increase) and intravenous antibiotic charges (39% increase). There are studies which states that blood culture contamination caused by coagulase-negative staphylococci. Souvenir et al. reported that almost half of the patients with a false-positive result were treated with antibiotics, often with vancomycin[13]. Segal and Chamberlain estimated that the additional charges associated with contaminated cultures in 85 children aged 3 to 36 months who were evaluated in an emergency department and believed to be at risk for occult bacteraemia totaled $78,904, the majority of which was due to subsequent hospital admission.[14] In another retrospective study of 9,959 blood cultures performed in children aged 1 month to 18 years, Thuler et al. found that 26% of children with false-positive cultures who were initially evaluated as outpatients were subsequently admitted to the hospital on the basis of initial culture results[15]. Measured in costs or charges, there is compelling evidence that the financial impact of blood culture contamination is significant.

Our study was done as a pilot study for just two months each, there was overall contamination rate of about 10.8% and in the ICU alone the contamination rate was 12.6%. After the intervention, we found that there was decrease in the contamination rate in the ICU from 12.6 % to 5.3%. This in turn reduced the length of stay and drastically reduced the expenses .There was also a decrease in the use of antibiotics. In the pre-intervention stage, more numbers of false positive blood culture results were there and antibiotic was changed based on those reports, where as in the post intervention period, the number of false positives decreased significantly which in turn decreased the antibiotic usage. The false positive cultures increased the length of stay, in turn increased the patient charges by

about Rs 5000/day compared to patients with negative blood cultures.

At our hospital the median Length of stay for patients with false positive blood cultures was 1 day longer than that for patients with negative blood cultures results Bates and Colleagues also found a trend towards increased length of stay . There are many other studies also quoting the same[7]. In an era of rising health care costs, the financial impact of false positive blood cultures is significant. If a fulltime dedicated phlebotomist is appointed, the potential reduction in the overall contamination can be reduced to a significant extent.

5. CONCLUSION AND IMPLICATIONS OF STUDY:

Clearly, progress has been made on several fronts in the battle against blood culture contamination. Better strategies for preventing contamination in the first place are being established, and we are improving our ability to distinguish contamination from true bacteraemia. New research on measures to estimate the pretest likelihood of bacteraemia offers promise in reducing unnecessary blood culture utilization. Despite the progress that has been made, however, significant barriers remain. In an era of rising health care costs, the financial impact of false-positive blood cultures is significant. The results of the two phases of study (one before the intervention and one after the intervention) were compared. Though it was a pilot study of just two months, involving mainly the ICU, there was a significant fall in contamination rates from 12.6% to 5.3% and subsequent decrease in health care costs during the second phase, Hence the same can be followed in other wards thus decreasing the contamination rates and in turn decreasing the misuse of antibiotics and thus decreasing financial burden of the patients.

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Conflict of Interest: None Declared

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