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Original Article

Determination of Blood Culture Contamination Rate at a Tertiary Care Hospital

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ABSTRACT

Objective: To determine bacterial contamination rates in blood culture specimens received at Microbiology Department, Armed Forces Institute of Pathology, Rawalpindi Pakistan.

Study Design: Cross-sectional study.

Place & Duration of Study: Department of Microbiology, Armed Forces Institute of Pathology & Combined Military Hospital, Rawalpindi Pakistan, from Aug to Dec 2022.

Methodology: All the blood culture samples signaled positive on automated blood culture system, were sub cultured on appropriate media for identification of isolates. The skin flora was labeled as contaminant, if fulfilled the criteria as per operational definition. The clinical history and other required data was incorporated in Excel sheet and was analyzed.

Results: The total number of blood cultures received was 1816, of which 425 were signaled positive by the system. Of the total blood cultures, 260(14%) were identified as contaminants including Coagulase negative Staphylococcus (83.%), Corynebacterium spp. (10.4%), Bacillus spp. (4.2%) and Micrococcus (2.3%). These organisms were identified as contaminants after thorough evaluation of the clinical condition of the patients. The highest blood culture contamination rate (23%) was observed in samples received from neonatal Intensive Care Unit (ICU), followed by paediatric ICU& paediatric wards.

Conclusion: In our study the overall blood culture contamination rates are found to be higher than internationally accepted rate with the highest contamination rates are found to be in the neonatal ICU and paediatric wards. Therefore, comprehensive plan of training the relevant healthcare workers (HCW) is recommended with strict monitoring to minimize the blood culture contamination rate to the internationally acceptable level.

Keywords: Blood culture, Contamination rate, Coagulase negative staphylococci, Bloodstream infections.

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INTRODUCTION

Bloodstream infections (BSIs), include bacteraemia i.e. presence of viable bacteria and fungaemia i.e. presence of fungi or yeast in the blood.[1] BSIs are the significant cause of morbidity and mortality among patients worldwide.[2,3] Despite advancement in various molecular techniques such as polymerase chain reaction (PCR), blood culture (BC) is still the most sensitive and reliable method4 and is taken as gold standard to diagnose BSIs and isolation of pathogens. Blood cultures therefore contribute significantly in timely directing antimicrobial therapy.[5] The World Health Organization (WHO) has recently acknowledged the importance and clinical significance of BC in monitoring resistance to antibiotics due to its precise and reliable results.[6] In the recent years, automated and semi-automated blood culture systems i.e., BACTEC (BD Diagnostics, USA) and BacT/ALERT® 3D (Biomerieux, Germany) have shown greater sensitivity and specificity for microbial identification as compared to conventional manual methods.[7]

Clinical microbiology laboratories must possess the expertise to correctly interpret the blood culture results so that blood stream infection can be documented or ruled out. Positive blood cultures are generally considered to have high positive predictive value for the presence of pathogenic organisms. However, false positive cultures are sometimes reported, which are termed as Contaminated Blood Cultures (CBCs).[8] Contamination occurs when microorganisms which are not actually present in bloodstream grow in blood culture.[9] These contaminants are get entry into the blood culture either during phlebotomy or handling and are not of any clinical significance, except in certain conditions like immunocompromised patients.[10] Blood Culture Contamination (BCC) occurs most often during phlebotomy because when the phlebotomy needle pierces through the skin during venipuncture, the bacteria constituting flora of skin, sebaceous glands and hair follicles, get incorporated in the blood sample. Blood culture contamination can be reduced

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in many ways e.g. thorough asepsis of skin, disinfection of the cap of blood culture bottle, use of standardized BC kits & specially trained phlebotomy staff.[11,12] Blood cultures collected by peripheral venipuncture are also found to have lower contamination rates than those obtained from indwelling intravenous catheters.[13]

The National Healthcare Safety Network has defined blood culture contamination (BCC) as "The growth of ≥1 of the normal skin flora comprising of Coagulase Negative Staphylococci (CoNS), Aerococcus, Micrococcus, Propionibacterium spp., Bacillus spp. (excluding Bacillus anthracis), Corynebacterium species (diphtheroids), and α-hemolytic viridans group Streptococci in a single blood culture, that is, in only one bottle in a series of blood culture sets.[5] Numerous microorganisms attributed to blood culture contamination can also be the cause of serious fatal infections. CoNS are the most frequent contaminants in blood culture; however, they can be a cause of nosocomial infections in immunocompromised individuals or patients with indwelling intravenous catheters.[14] So, whenever contaminants are observed in a blood culture it is necessary to correlate with clinical symptoms, inflammatory markers, positivity in paired/single cultures and use of indwelling devices etc., to rule out possibility of pathogenic role of the contaminant.[5]

Even in this modern era, it is not possible to get contamination free blood cultures in clinical settings. BCC rates vary in the literature, ranging from 3 to 12%.[9] According to Clinical and Laboratory Standards Institute (CLSI) and American Society for Microbiology (ASM), blood culture contamination rate should be less than 3%, which is standard benchmark.[11]

Blood culture contamination rate directly reflects the quality of patient care at any healthcare management system. This is because reduced BCC rate would help avoid undue administration of antibiotics, reducing not only financial expenses but risk to patient life. Therefore blood culture contamination rates must be monitored regularly in order to keep BCC rate within standard limit.[7] Clinical laboratories are required to monitor blood culture contamination rate on monthly basis to ensure the quality of care and services provided by healthcare unit.

Unfortunately, a deficiency exists in the current knowledge regarding rates of blood culture contamination in Pakistan. The objective of this study was to determine the blood culture contamination rate at our healthcare facility so that appropriate measures could be taken if the rates are found higher than acceptable international standards.

METHODOLOGY

It was a cross-sectional study that was conducted at Department of Microbiology, Armed Forces Institute of Pathology (AFIP) & Combined Military Hospital (CMH), Rawalpindi from August 2022 to December 2022. The sample size was calculated to be 1816 using formula,[15]

$$n = \frac{z^2 \times p(1-p)}{\varepsilon^2}$$

keeping confidence level (z) 95% (1.96), margin of error (Ɛ)±2.3% (0.023) and population proportion 50%. Non-probability consecutive sampling technique was used.

Inclusion Criteria: The blood culture specimens (single/paired) collected in aerobic, anaerobic and pediatrics culture bottles of BacT/ALERT® (BioMerieux, Germany) irrespective of age and gender, received for culture and sensitivity testing were included in the study.

Exclusion Criteria: Blood culture specimens received in manual, non-automated & semi-automated culture bottles were not included in the study.

Study proposal was approved for ethical concerns by the Institutional Review Board (IRB) via certificate no. BSAHS/MIC-3/IRB/22/1359 dated July 8, 2022.

Blood cultures received in BacT/ALERT® culture media bottles i.e., BacT/ALERT® SA (aerobic), BacT/ALERT® SN (anaerobic) or BacT/ALERT® PF (pediatric) were incubated in the automatic blood culture equipment, the BacT/ALERT 3D system at 37°C as per manufacturer's instructions. In case of blood cultures flagged positive by BacT/ALERT, gram stain was performed for rapid preliminary identification of microorganism and then positive blood cultures were inoculated on culture media plates including blood, chocolate & MacConkey agars and incubated at 37°C for 18-24 hours. In case of no signal of growth by the automated blood culture system, blood culture bottles were continued to incubate for maximum 7 days. Culture plates showing growth were further processed by Gram's staining. All the samples yielding growth of gram positive cocci or gram positive rods were further processed using standard microbiological procedures. Preliminary bacterial identification included colony morphology,

catalase test, coagulase test, oxidase test, motility test, bile solubility test, pyrase test, growth in 6.5% NaCl test & bile aesculin hydrolysis test. Vitek Automatic Bacterial Identification System was used for final identification of the isolates.

For all samples tested positive for skin flora, clinical details were obtained by self-organized data collection form to rule out known history of immunosuppression e.g. cancer, chemotherapy, transplant etc. Growth of Coagulase Negative Staphylococcus, Micrococcus spp., Bacillus spp, Corynebacterium spp. (diphtheroids), Cutibacterium spp., Aerococcus spp., Alpha-Hemolytic Viridans Streptococci were considered as contamination, if there was no known history of immunosuppression or growth in one of the paired blood culture bottles in case of patients from oncology and transplant wards.

The BCC rate (%) was calculated as:

$$\text{Blood culture contamination rate (\%)} = \frac{\text{Number of samples with growth of contaminants}}{\text{Total number of blood cultures}} \times 100$$

Data was incorporated in the Microsoft Excel 2010 sheet. Frequencies and percentages of the qualitative variables were also calculated using Microsoft Excel 2010.

RESULTS

A total of 1816 blood culture samples, dealt with in the microbiology laboratory from 1st of August 2022 till 4th of November 2022, were considered for determination of blood culture contamination rate. Out of all the blood cultures received, 425(23.40%) were found positive for bacterial growth of both true pathogens and contaminants. As per our operational definition of blood culture contaminants, growth of isolates in 260 out of 1816 positive blood cultures was declared as contaminants constituting a blood culture contamination rate of 14% (Figure-1).

Out of 260 blood culture specimens which revealed the growth of contaminants, 154(60%) were of males, while 106(40%) were of females. Blood culture samples were received from a total of 30 departments of the hospital including both indoor and outdoor patients of all age groups ranging from 01 day to 99 years. Contamination was observed in blood cultures received from 24 out of 30 departments. Out of these 24 departments, 8 departments constituted 80% of the 260 samples yielding growth of contaminants, with the highest burden being shared by pediatric ward (23.1%) followed by neonatal ICU (13.5%), lab reception (10.45%), child ward (10%), pediatrics ICU (7.7%), outpatient department (7.3%), medical ICU (5.4%) and officers ward (4.6%). Based upon the total number of blood culture specimens received from each department, departmental blood culture contamination rate was also calculated independently for the departments from which sufficient blood culture samples were received. Different wards of the paediatric department were found to have the highest BCC rate ranging from 19-23%. More than 50% of the 24 departments were calculated to have BCC rate higher than the internationally accepted benchmark of 3% (Figure-2).

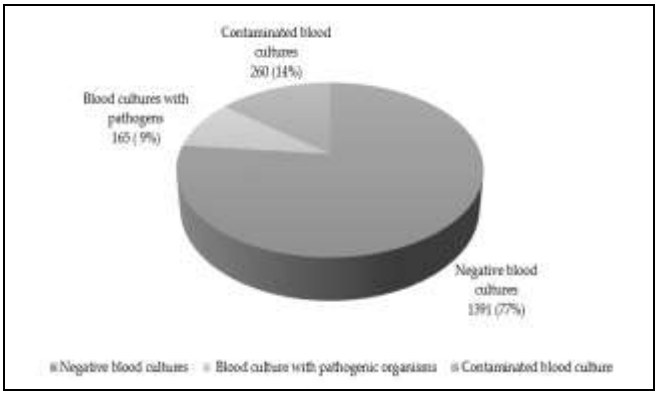

Figure-1: Distribution of Positive and Negative Blood Cultures (n=1816)

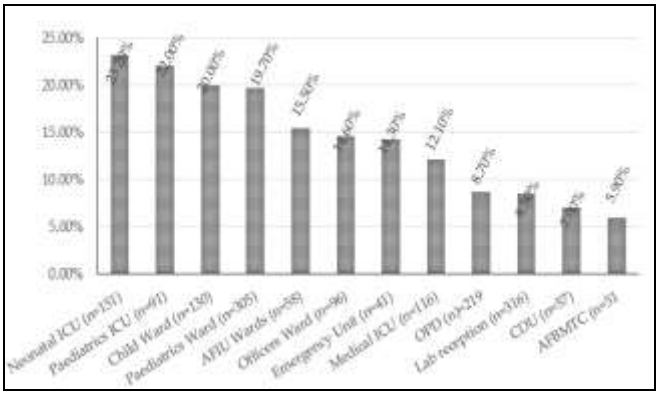

Figure-2: Departmental BCC Rate

Out of the 260 contaminated blood cultures, maximum number of samples 89(34%) was received from infants falling in age group 0-1 year followed by pediatrics population with age group 1-10 years 68(26%). Blood culture contamination rates were generally higher than internationally accepted rate during study period. Highest contamination rate was observed in August (16.72%) followed by September (15.63%) and October (10.19%). (Table-1)

The most prevalent organism among contaminated blood cultures was Coagulase Negative Staphylococcus 216(83%), followed by Diphtheroids 27(10.4%), Bacillus 11(4.2%) and Micrococcus 6(2.3%).

Table-I: Month-wise Prevalence of Blood Culture Contamination

Month	Total Blood Culture Specimens (n)	Rate of Blood Culture Contamination n(%)
August	592	99 (17.0)
September	665	104(16.0)
October	559	57 (10.0)
Total	1816	260 (14.0)

Table-II: Distribution of organisms isolated from CBCs

Contaminant	Frequency n(%)
Coagulase Negative Staphylococcus (CoNS)	216(83.0%)
Corynebacterium species (Diphtheroids)	27(10.4%)
Bacillus species	11(4.2%)
Micrococcus	6(2.3%)
Total	260

DISCUSSION

Blood culture contamination rate serves as an important marker for determining and maintaining the quality of patient care and healthcare services to an appropriate standard.[16] If the BCC rate is lowered it will reduce the possibility of patients' exposure to unnecessary antimicrobial agents and their possible side effects. Conversely a high BC contamination rate would lead to undesirable outcomes like increased hospital stay of up to 5 days, resulting in increased hospital charges, increased expenses & unwarranted antibiotic use, contributing to increase in antimicrobial resistance, antibiotic associated side-effects and allergic drug reaction.[6] This emphasizes the need for regular monitoring of the blood culture contamination rate and all efforts must be put in to keep it within the acceptable international limits.

The aim of current study was to determine the rate of blood culture contamination, the spectrum of contaminants and identification of weak areas in our set up. The overall blood culture contamination rate in our healthcare setting was found to be 14%, which is far above the benchmark of 3% as recommended by the American Society of Microbiology. Worldwide the blood culture contamination rate has been reported to fluctuate between 0.6% & 12.5%.[17] Blood culture contamination incidence of 10.4% was recorded in study from Nigeria.[18] A study conducted by Tenderenda et al. in a general hospital, Poland reported BCC to be 9.5% during defined study period.[8] Lalezari *et al*., found that 50% of all positive blood cultures yielded growth of contaminants.[19] Randomly observed factors contributing to a high contamination rate of 14% in our study, include non-adherence to the standard BC sampling procedure e.g. omitting steps like hand hygiene, wearing gloves, lack of sterile gloves, inadequate skin antisepsis & omitting disinfection of BC bottle cap. Increased work load and poor patient to nursing staff ratio in our hospitals is often attributed for this non-compliance to standard BC sampling procedure. However exact causes of increased blood culture contamination rates are needed to be studied, to focus on the targeted corrective actions, which was beyond the scope of our study.

In our study, Coagulase Negative Staphylococcus (CoNS) was the most frequent (83.07%) organism isolated from CBCs, followed by other skin flora i.e., Diphtheroids (10.4%), Bacillus species (other than bacillus anthracis) (4.2%) and Micrococcus (2.3%). This is in accordance with previous published reports where CoNS were found to be the predominant contaminant (84.3%) at General Hospital, Poland.[8]

It is extremely important to identify the departments in a hospital contributing maximally towards high blood culture contamination rate so that remedial measures can be focused in these areas. In our study, it was observed that maximum contaminants were isolated from samples of indoor patients (80%) as compared to outdoor patients (20%). The highest BCC rate of 23.2% was observed in neonatal ICU followed by paediatric ICU, paediatric ward and child ward having BCC rates of 22%, 20% and 19% respectively. Yunus *et al*., has also reported the highest contamination rate among pediatrics intensive care units and emergency (32.9%).[20] BCC rate of 20% was reported by Krause *et al*., in pediatrics department6. Difficulty in collecting blood samples from neonates and children, likely accounts for the higher contamination rate in these units.

A retrospective study done by Hemeg *et al*., reported that contamination rate was generally higher (54%) in the males.[5] This aspect was in line with our findings where 60 % of the samples yielding contaminants were isolated from male as compared to 40% from female patients. This is likely because more number of blood culture specimens were received from male patients. In our study 154 out 1045 BC samples from male patients and 106 out of 771BC

samples from female patients revealed growth of contaminants giving BCC rate of 14.7% in males and 13.7% in females.

We further analyzed BCC rate among different age groups and found that highest rate of contamination (34.2%) was found in infants of less than 1 year, followed by pediatrics population <10 years of age. Various studies have observed a similar association of age with BCC. A study done by Min *et al*., showed highest contamination rates in children less than 1 year.[21] Yunus *et al*., found that the children of less than 5 years were affected more by BCC.[14,20] Another study done by Chukwuemeka *et al*., in Nigerian Hospital also reported high contamination rates (11%) among pediatric patients.[18] Young children are often non co-operative rather try to resist giving blood sample due to fear of needle prick or fear of unknown procedure thus likely contributing towards contamination of blood cultures.

In our study, we observed a high BCC rate in summers with the highest being found in August (17%) followed by September (16%), October (10%) & November (7.23%). These results are in concordance with previous studies where higher BCC rates have been observed in summer season. Alnami *et al*., conducted a study at King Khalid University Hospital in Saudi Arabia & observed that maximum BCC occurred in summer.[7] Yunus *et al*., also reported the maximum BCC rate of 13.6% in the summer month of July.[20] A Korean paper by Min *et al*., has also reported the highest BCC rate in August.[21]

As per operational definition of BCC in our study, we ruled out only known history of immunosuppression from available medical record, for labeling growth of skin flora as contaminants. However immunosuppression has not been ruled out by any additional lab tests. Also other risk factors like long-term intravascular catheterization, peritoneal dialysis or hemodialysis and raised inflammatory markers like white cell count, Neutrophil count and C-reactive protein (CRP) have not been ruled out in our study as included by some other studies.[5] Probing the reasons of increased blood culture contamination rate and interventions to mitigate it have also not been incorporated in our study and are recommended to be further investigated.

CONCLUSION

The current study revealed that rate of blood culture contamination is significantly higher than internationally accepted rate. In order to reduce BCC rate, there is urgent need of implementing a comprehensive training plan for personnel who obtain blood samples. Departments with high contamination rate such as pediatrics deaprtment should be targeted and intervened to improve the quality of healthcare services. A prospective study should be done to identify the main factors responsible for the blood culture contamination and to evaluate the impact of interventions like different methodologies of training the phlebotomists & nursing staff etc.

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Authors' Contribution

Following authors have made substantial contributions to the manuscript as under:

SHN & EA: Data acquisition, data analysis, critical review, approval of the final version to be published.

IAM: Study design, data interpretation, drafting the manuscript, critical review, approval of the final version to be published.

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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