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Efforts to improve diagnosis of bacteraemia by reducing blood culture contamination in an emergency department: Strategies and outcome

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RESEARCH ARTICLE

Efforts to improve diagnosis of bacteraemia by reducing blood culture contamination in an emergency department: strategies and outcome

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Abstract

Objective: To assess the strategies and outcome for reducing blood culture contamination in order to improve the diagnosis of bacteraemia.

Method: The interventional study was conducted at a tertiary care hospital in Karachi from January 1, 2013, to December 31, 2016. The blood culture contamination data related to the first year of the study was taken as the baseline pre-intervention data. Strategies were planned as intervention for improvement by consolidating training and education in the form of dedicated lectures, practising on mannequins and developing in-house video, replacing povidone with 2% chlorhexidine preparation spray plus 70% isopropyl alcohol swabs and inducting dedicated phlebotomy team whose only responsibility was blood sample collection and minimising the probability of error.

Results: In 2013, there were 8868 samples; 7402 in 2014; 6897 in 2015; and 9756 samples in 2016. The contamination rate in 2013 was 8% which went down to 7.75% in 2014, 4.25% in 2015 and 3.9% in 2016. The decline became statistically significant ($p<0.001$) after implementing a dedicated phlebotomy team in the emergency department.

Conclusion: Apart from teaching and training, the concept of blood culture collection kit with checklist and dedicated blood collection team was found to be vital in reducing blood culture contamination.

Keywords: Blood culture, Contamination rate, Dedicated phlebotomy team. (JPMA 70: 835; 2020).
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Introduction

In the era of emerging pathogens and developing antimicrobial resistance, blood culture is an essential diagnostic component of infectious disease work-up. Early microbial identification and susceptibility pattern has become essential to reducing the morbidity and mortality in patients. In microbial culture and sensitivity testing, the validity of result and its interpretation mainly depends on pre-analytical process of proper specimen collection. Introduction of normal skin flora and environment contaminants during blood culture specimen collection interferes with the growth of actual causative agents of blood stream infection. Occasionally, due to culture contamination, microbiological evidence for the clinical diagnosis remains obscure. This could lead to erroneous diagnosis. Additionally, starting inappropriate antibiotics not only compromise quality care and patient morbidity, but also promote antibiotic resistance.[1] The consequential financial impacts not only stand by the patient himself but it also implicates the hospital in terms of resource wastage, extended hospital bed occupancy and provision of inadequate therapies.[2,3]

Therefore, monitoring blood culture contamination rate is an important healthcare quality indicator. According to the international quality audit and benchmark, acceptable blood culture contamination rate is $\leq$3%.[4] The presence of coagulase-negative staphylococcus (S.) species, corynebacterium (C.) species (diphtheroids), bacillus (B.) species, micrococcus (M.) species and streptococcus species in a series of blood culture is generally considered contaminants and do not have any significance unless associated with some important clinical scenario e.g. endocarditis, central line associated blood stream infections (CLABSI) or repeated positive blood culture with above mentioned microbes.[5]

Being a multi-disciplinary hospital which maintains high-quality healthcare, persistent raised false positive (FP) blood culture rate was an area of concern for our hospital and laboratory quality-improving team.

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In the emergency department (ED), after the initial clinical assessment, all relevant laboratory tests are sent to the clinical laboratory. In cases of suspected bacteraemia/ sepsis, patient's blood culture is drawn by nurses or doctors which is followed by empirical antibiotic therapy. Contamination at this point may misguide the physician and can delay switching to the appropriate antibiotic. To overcome this wide-reaching issue, many hospitals have adapted strategies to minimise this.[6,7] Blood culture contamination monitoring has been one of important indicators of microbiology laboratory. During 2013, monthly blood culture contamination data revealed that ED has been continuously responsible for the highest blood culture volume as well as contamination rate. This was not acceptable in view of international quality standards.

Therefore, the current study was planned to reduce blood culture contamination in ED by consolidating training/teaching and other strategies.

Material and Methods

The interventional study was conducted at a tertiary care hospital in Karachi from January 1, 2013, to December 31, 2016. The study site is one of the largest private tertiary care units of the country having more than 700 inpatient beds. It has many clinical units and an ED which caters to hundreds of medical and surgical emergencies daily. After getting exemption from the institutional ethics review committee, the four-year study period was divided into pre-intervention and intervention periods. The blood culture contamination data between January 1 to December 31, 2013, was taken as the baseline pre-intervention period (Figure 1). The next three years represented the intervention period. January 1 to December 31, 2014, was the period of first intervention, while January 1, 2015, to December 31, 2016, was the period of second intervention.

In the pre-intervention period, nursing staff, residents and intern doctors working in ED were generally responsible for collecting blood culture of patients. During this period, routine strategies were strengthened to control blood culture contamination rates. These included didactic lectures and formal education sessions for nurses and doctors, mainly interns and new residents, delivered by microbiology staff. Monthly laboratory data monitoring of blood culture contamination was evaluated regularly and feedback was provided to head nurse of the unit.

During the first intervention period, additional strategies were added. These included monthly small group interactive sessions conducted by a dedicated microbiology team which included doctors and technical staff. The main aim of this session was to improve awareness about maintaining sterility care during blood culture collection procedure. Other strategies introduced during this period included introduction of blood culture collection kit with a flyer explaining pictorial blood culture collection procedure, blood culture bottle, disinfectant and syringes, replacement of povidone iodine with 2% chlorhexidine preparation spray plus 70% isopropyl alcohol (IPA) swabs, blood culture collection practice on mannequins, local language-based video preparation on blood culture collection technique, which was accessible on hospital's website portal. To increase compliance of sterile technique, a checklist was implemented during blood culture phlebotomy in view of Clinical and Laboratory Standards Institute (CLSI) recommendations.[8]

In addition to the above strategies, the laboratory introduced a team of dedicated phlebotomy technicians in the second intervention period for collecting blood culture samples in ED. The main purpose of this team was to minimise the chances of error during specimen collection. They were trained by all the above strategies, including formal interactive discussions by the microbiology team.

As this was a quality project, therefore blood cultures of all patients who visited the ED, and collected from peripheral venipuncture of both adult and paediatric population were included for evaluation. Blood collected through central venous catheters was excluded. Microorganisms considered to be contaminants for the study purpose were coagulase-negative staphylococcus (CoNS) isolated in single blood culture from peripheral venipuncture, and corynebacterium and bacillus species isolated in single blood culture from peripheral venipuncture.

Any CoNS isolated from central venous catheter or isolation of CoNS with similar susceptibility pattern of any patient in $\geq$2 clinical samples was considered to be pathogens and excluded. Percentage contamination rate was calculated as total number of contaminant divided by total number of blood culture collected by venipuncture.[4]

Data was entered into Microsoft Excel sheet and paired

t-test was applied to calculate the statistical significance using software Stata/SE 12.1. Finally, blood culture contamination rate was shared with ED on a monthly basis.

Results

In 2013, there were 8868 samples; 7402 in 2014; 6897 in 2015; and 9756 samples in 2016. The contamination rate in 2013 was 8% which went down to 7.75% in 2014, 4.25% in 2015 and 3.9% in 2016 (Figure 1).

A monthwise review of contamination rate (Figures 2-3) showed the downward trend starting at the end of 2014 which reduced to half over the next two years (2015-16). This difference was statistically significant (p<0.001) (Table 1).

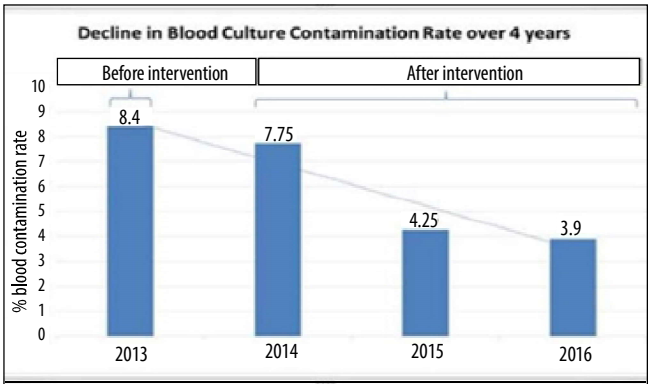

Figure-1: Mean blood culture contamination rate over 4 years 2013-2016

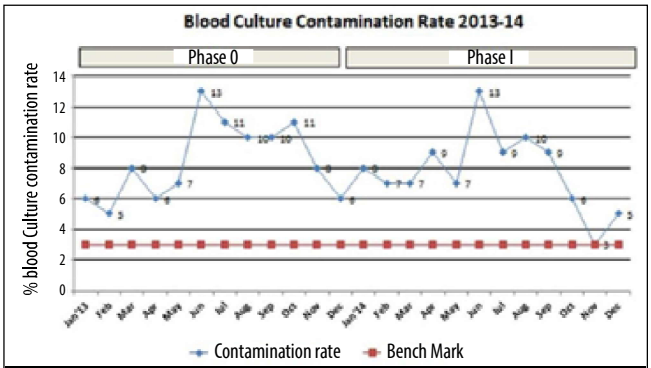

Figure-2: Blood culture contamination rate in Emergency department in year 2013-2014

Table: Statistical analysis with and without intervention over 4-year period.

Variable	Years	Mean contamination rate (%)	CI [95%]	*p*-value
Without Phlebotomist	2013-2014	8.083	7.020 to 9.146	< 0.0001
With Phlebotomist	2015-2016	4.083	3.527 to 4.639	

CI: Confidence interval.

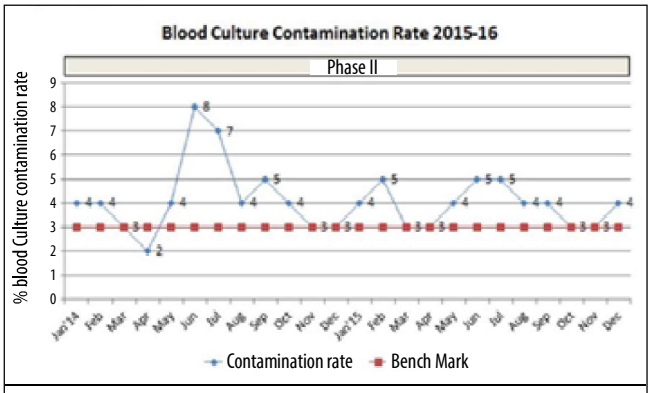

Figure-3: Blood culture contamination rate in Emergency department in year 2015-2016.

Discussion

To the best of our knowledge, the current study is the first report from Pakistan highlighting the successful outcome of a continuous team effort to overcome blood culture contamination issue in a busy hospital unit. During 2013, the rate of blood culture contamination rate from ED used to be between 5-13% of total submitted blood cultures. For any busy hospital unit, overcrowding and stressful working environment contribute to poor patient services and are identified risk factors for increased blood culture contamination.[9,10] In our situation, besides these highlighted factors, there is an additional potential factor of hot and humid weather of Karachi. Warmth and exceedingly high temperature lead to increased perspiration, alteration of normal skin microbiota and poor skin hygiene that in turn could lead to increased probability of contamination during specimen collection, especially if sterility measures are not taken appropriately.[11] While performing observatory rounds and conducting detailed discussions with doctors and paramedics during the pre-intervention period, several additional contributory factors were highlighted for persistently elevated rate of blood culture contamination from the ED. These factors were non-conformity in standardised culture collection practices by the nurses and junior doctors, fast-paced environment due to high patient influx and stressful working conditions, causing reduced time for specimen collection and therefore compromised specimen.[12] Clinicians and paramedics are generally ignorant of implications of blood culture contamination and also unaware that it is used as an important quality indicator in healthcare service provision. The situation was similar in our hospital and therefore clinical microbiology in coordination with ED had taken

initiative for introducing initial relevant measures to improve the situation. During that pre-intervention period, efforts were made to consolidate training and existing practices by doing regular education activity e.g. didactic lectures. However, catering to large number of healthcare workers in one large forum was an uphill task. In order to improve the practices of nurses and junior doctors, handouts and didactic lectures regarding blood culture collection technique was given in different wards, including ED. However, the quality improvement was not very satisfactory.

Therefore, for 2014, small group interactive sessions and hands-on training on mannequins for blood culture specimen collection after scheduled regular interval were arranged and phlebotomy checklist in view of CLSI documents[8] was prepared. To consolidate these activities, in-house video regarding proper specimen collection was developed in Urdu language and uploaded on hospital's webpage. Healthcare workers were encouraged to view and improve their sample collection practices. In line with other studies, our data testify that conventional teaching and computer-assisted learning strategies were not very effective in strengthening the skills.[13,14] During this phase, 2% (w\v) chlorhexidine and 70% IPA was introduced as an antiseptic as povidone iodine is a relatively less effective skin disinfectant plus it requires >30 seconds of contact time which is difficult to follow in a busy ED scenario.[15] During the training session, doctors, nurses and phlebotomists were informed about the importance of contact time of different disinfectants. Although decreasing trend started to appear after 21 months of the first phase (end of year 2014), but we observed that despite these strategies, the reduction in contamination was negligible (<1%) from the baseline data of year 2013. (Figure 2). Thereafter, the second intervention was planned to introduce in 2015 with continuation in 2016. Teams of phlebotomists were scheduled to work in two out of three shifts of a day (morning and evening), seven days a week. They were dedicated for blood specimen collection only by using the provided collection kit and with strict adherence to the checklist. Fortunately, after introducing dedicated phlebotomists with mentioned prerequisites reduction in blood culture contamination rate moved to almost half from the baseline at 36 months (end of year 2015) which remained sustained after 48 months (year 2016) (Figure 3). The difference became statistically significant after the implementation of phlebotomy team ($p<0.0001$). The gradual decline in mean blood culture contamination rate was observed over 3 years. This reflects that adequate time must be given to observe the impact after implementing any changes in routine practices, and requires close and regular follow-ups. The clinical outcome and financial impact due to FP blood culture were not the objectives of our study and that was a limitation of the study. There could be a possibility of financial constraints by hospital management for hiring a team of phlebotomists. Studies in countries having good healthcare infrastructure have shown overall significant cost reduction by having reduced blood culture contamination.[16-20] Another observation during the study was the trend of high blood culture contamination from June till September. In our opinion, the extreme hot and humid weather of the city during this period could be the possible reason, as high temperature promotes more spore germination and causes increased bacterial load. Increasing infection rate with changing weather also increases ED visits. Also, generally this is the monsoon season during this time of the year in this region and ED influx increases usually due to other acute febrile illness e.g. dengue fever, malaria and other waterborne diseases. For febrile workup, blood culture is an essential component. High patients load in ED along with increased blood culture collection during this season and probably with high bacterial load might be the cause of high contamination rate.[21,22]

In resource-limited countries where laboratory diagnostic facilities, especially in public hospitals, are not up to the mark and the patient generally bears the cost by submitting the clinical samples to private laboratories, introducing a specialised dedicated team who works under less pressure and has dedicated time for collecting blood for culture can reduce the contamination rate. Finally, as blood culture is an important tool in antibiotics stewardship plan, this effort can help to isolate and identify real pathogens, which can direct the appropriate and timely antibiotic therapy to the patients.

Conclusion

Continuous and vigilant efforts, including close liaison and feedback mechanisms between clinical laboratory, physicians and paramedics, was found to be essential in bringing down contamination rate. Concept of blood culture collection kit with checklist and dedicated specimen collection team were helpful steps to reduce

blood culture contamination.

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