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Blood culture contamination in Babcock University Teaching Hospital, Nigeria: A five-year retrospective study

[1,2]Oluwole, T. O., *[1,2]Otaigbe, I. I., [1]Okunbor, H. N., [1]Osinowo, A. O., and [1,2]Elikwu, C. J.

[1]Department of Medical Microbiology and Parasitology, Babcock University Teaching Hospital, Ilishan-Remo, Ogun State, Nigeria
[2]Department of Medical Microbiology and Parasitology, Benjamin (S) Carson (Snr) College of Health and Medical Sciences, Babcock University, Ilishan-Remo, Ogun State, Nigeria
*Correspondence to: otaigbei@babcock.edu.ng; +2348024406763

Abstract:

Background: Bloodstream infections are a leading cause of morbidity and mortality among in-patients globally. Blood culture is the 'gold standard' test for the diagnosis of bloodstream infections. The value of this valuable investigation in the diagnosis of infections however may be affected when an organism of questionable evidence is isolated, which occurs mainly due to contamination during the pre-analytical phase. Blood culture contamination can lead to the administration of unnecessary antibiotics, wastage of hospital resources, and risks to patient life. Hence, this study aimed to analyse the blood culture contamination rate in a private tertiary hospital in southwest Nigeria.
Methodology: This was a retrospective observational study of patients with clinical features of bloodstream infections at Babcock University Teaching Hospital, Ilishan-Remo, Ogun State, Nigeria between January 2018 and December 2022. Blood culture results of patients in the wards or units of the hospital were reviewed, and contamination rates and organisms isolated from positive blood cultures were documented. Data were analysed using SPSS version 22.0
Results: A total of 1,612 non-repetitive blood cultures were obtained from 1,612 patients (910 males and 702 females) during the study period, out of which 397 (24.6%) were positive, 1215 (75.4%) were negative, and 124 (7.7%) were deemed as contaminants. The contamination rate was higher in females (8.7%) than in males (6.9%), although the difference was not statistically significant (x^2=1.501, OR=0.7816, 95% CI=0.5416-1.128, p=0.2204). The contamination rate was higher in adults (8.1%) than children (7.3%) with the highest contamination occurring in the age group 35-39 years (9.0%), although the difference was not statistically significant (x^2=0.3227, OR=0.8835, 95% CI=0.6120-1.276, p=0.5700). The female surgical ward (11.9%) had the highest contamination rate while the accident and emergency had the lowest contamination rate (1.3%) but the difference was not statistically significant (x^2=11.825, p=0.2970). Coagulase-negative staphylococci were the predominant blood culture contaminants. The contamination rate increased during the 5 years from 4.8% in 2018 to 9.4% in 2022
Conclusion: The rate of blood culture contamination in our study is higher than the acceptable international rate, and mainly due to normal skin microbiota, suggesting challenges during sample collection. There is a need for a multidimensional approach to minimize blood culture contamination and hence avoid unnecessary antibiotic use.

Keywords: Blood culture contamination, false-positive cultures, Coagulase-negative staphylococcus

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Contamination des hémocultures au Hôpital Universitaire de Babcock, Nigeria: une étude rétrospective sur cinq ans

[1,2]Oluwole, T. O., *[1,2]Otaigbe, I. I., [1]Okunbor, H. N., [1]Osinowo, A. O., et [1,2]Elikwu, C. J.

[1]Département de Microbiologie Médicale et de Parasitologie, Hôpital Universitaire Babcock, Ilishan-Remo, État d'Ogun, Nigeria
[2]Département de Microbiologie Médicale et de Parasitologie, Benjamin (S) Carson (Snr) Collège de la Santé et des Sciences Médicales, Université Babcock, Ilishan-Remo, État d'Ogun, Nigéria
*Correspondance à: otaigbei@babcock.edu.ng; +2348024406763

Résumé:

Contexte: Les bactériémies sont l'une des principales causes de morbidité et de mortalité chez les patients

hospitalisés dans le monde. L'hémoculture est le test de référence pour le diagnostic des infections sanguines. La valeur de cette enquête précieuse dans le diagnostic des infections peut cependant être affectée lorsqu'un organisme dont les preuves sont douteuses est isolé, ce qui se produit principalement en raison d'une contamination au cours de la phase pré-analytique. La contamination des hémocultures peut entraîner l'administration d'antibiotiques inutiles, un gaspillage des ressources hospitalières et des risques pour la vie des patients. Par conséquent, cette étude visait à analyser le taux de contamination des hémocultures dans un hôpital tertiaire privé du sud-ouest du Nigeria.

Méthodologie: Il s'agit d'une étude observationnelle rétrospective portant sur des patients présentant des caractéristiques cliniques d'infections du sang à l'hôpital universitaire Babcock, Ilishan-Remo, dans l'État d'Ogun, au Nigeria, entre janvier 2018 et décembre 2022. Résultats des hémocultures des patients dans les services ou unités de l'hôpital ont été examinés et les taux de contamination et les organismes isolés à partir d'hémocultures positives ont été documentés. Les données ont été analysées à l'aide de SPSS version 22.0

Résultats: Au total, 1612 hémocultures non répétitives ont été obtenues chez 1612 patients (910 hommes et 702 femmes) au cours de la période d'étude, parmi lesquelles 397 (24,6%) étaient positives, 1215 (75,4%) étaient négatives et 124 (7,7%) ont été considérés comme des contaminants. Le taux de contamination était plus élevé chez les femmes (8,7%) que chez les hommes (6,9%), bien que la différence ne soit pas statistiquement significative (x^2=1,501, OR=0,7816, IC 95%=0,5416-1,128, p=0,2204). Le taux de contamination était plus élevé chez les adultes (8,1%) que chez les enfants (7,3%), la contamination la plus élevée se produisant dans la tranche d'âge de 35 à 39 ans (9,0%), bien que la différence ne soit pas statistiquement significative (x^2=0,3227, OR= 0,8835, 95% IC=0,6120-1,276, p=0,5700). Le service de chirurgie féminin (11,9%) avait le taux de contamination le plus élevé tandis que le service d'accident et d'urgence avait le taux de contamination le plus faible (1,3%) mais la différence n'était pas statistiquement significative (x^2=11,825, p=0,2970). Les staphylocoques à coagulase négative étaient les principaux contaminants des hémocultures. Le taux de contamination a augmenté au cours des 5 années passant de 4,8% en 2018 à 9,4% en 2022.

Conclusion: Le taux de contamination des hémocultures dans notre étude est supérieur au taux international acceptable, et principalement dû au microbiote cutané normal, suggérant des difficultés lors du prélèvement des échantillons. Il est nécessaire d'adopter une approche multidimensionnelle pour minimiser la contamination des hémocultures et ainsi éviter l'utilisation inutile d'antibiotiques.

Mots-clés: Contamination des hémocultures, cultures faussement positives, staphylocoque à coagulase négative

Introduction:

Bloodstream infections are the leading cause of morbidity and mortality in hospitalized patients globally (1–4). Blood culture is the 'gold standard' in the diagnosis of patients with bloodstream infections and sepsis (3,5–7). The aim of blood culture is to isolate the pathogen and determine the appropriate antimicrobial agents for effective therapy. However, blood culture contamination results in a false positive, thereby limiting the utility of this valuable test (5,8). Blood culture contamination remains a source of frustration for clinical microbiologists and clinicians. Due to difficulties in the interpretation of a false positive blood culture, especially in a solitary culture, unnecessary administration of antibiotics can result in the emergence of drug resistant strains, drug interactions, increased cost of healthcare, prolonged hospital stay and increased morbidity and mortality (3,4,8,9).

Generally, blood culture contamination occurs during the collection and handling of blood specimens, before laboratory analysis (2, 5). A potential blood culture contaminant is an organism which commonly inhabits the human skin, which accounts for contamination in 50% of cases. The sources of contamination of blood culture include the skin of the patient, contaminated hands of healthcare providers and the equipment used for blood sampling or transfer. The common factors associated with contamination include inappropriate sampling, non-compliance with aseptic techniques, non-use of dedicated phlebotomists or personnel in blood collection, collection of blood from indwelling central venous catheters and difficulty in collecting blood from children and elderly patients (3–5,8,9). The common microorganisms that have been implicated as contaminants are the coagulase-negative staphylococci (CoNS)*, Micrococcus* spp, *Propionibacterium* spp, and *Bacillus* spp (2,4,8,9).

Blood culture contamination rate is commonly used as a key indicator of the quality of laboratory performance and patient care (3,8,9). The Clinical and Laboratory Standards Institute (CLSI) recommends less than 3% as the acceptable rate of blood culture contamination in a health facility (4,10). This study aimed to determine the blood culture contamination rate in a private tertiary teaching hospital in southwest Nigeria over a 5-year period.

Materials and method:

Study design and setting:

This was a retrospective study of blood culture results of patients with clinical features of bloodstream infections at the Medical Microbiology Laboratory of Babcock University Teaching Hospital, Ilishan-Remo, Ogun State, Nigeria between January 2018 and December 2022. This healthcare facility is a 200-bed, private tertiary hospital owned by the Seventh Day Adventist Church. It provides medical and surgical services to the host community, Ogun State as well as neighbouring Lagos, Oyo, Osun, Ondo and Ekiti States.

Ethical consideration:

Ethical approval was obtained from the Babcock University Health Research and Ethics Committee (BUHREC). Informed consent of patients was not required.

Blood culture collection and processing:

Routinely in the hospital, solitary blood cultures are usually collected from patients into BACTEC culture bottles (Becton Dickinson). All cultures are incubated in BACTEC blood culture machine at 35-37ºC and atmospheric pressure for a maximum duration of 5 days. Cultures indicating growth are routinely sub-cultured on solid media and incubated for 24-48 hours for isolation and subsequent identification of the microorganism by conventional microbiological identification tests.

Criteria to determine contamination:

The records of all blood cultures were reviewed, and information was sought from the managing physicians on the technique of blood collection. As there is no "gold standard" in the determination of contaminants, clues and criteria were followed to distinguish contamination from true infection (11). These included; (i) identity of the isolated microorganism such as coagulase-negative staphylococci, *Corynebacterium* spp and (ii) clinical status of the patient, history and laboratory findings such as presence of fever, leukocytosis or leukopenia and high C-reactive protein (CRP), or presence of foreign device. In summary, the contaminants were determined based on the isolation of a skin commensal and the patient's clinical scenario.

Data analysis:

Data were analysed using IBM SPSS for Windows, version 22 (IBM Corp., Armonk, N.Y., USA). Descriptive analysis was carried out for demographic, clinical characteristics and causative microorganisms. The blood culture contamination rate was calculated by dividing the number of contaminated blood cultures by the total number of routine blood cultures obtained and multiplying by a factor of 100.

Categorical variables were presented as frequencies and percentages. Mean and standard deviation were calculated for continuous variables. Categorical variables were compared using Fisher Exact or Chi-square test as appropriate. A p-value of less than 0.05 was considered statistically significant for all analyses.

Results:

A total of 1,612 blood cultures were obtained during the study period; of which 800 (49.6%) were blood specimens from paediatric patients while 812 (50.4%) were from adults. There were 910 (56.5%) males and 702 (43.5%) females. Of the total 1,612 cultures, 397 (24.6%) were positive and 1,215 (75.4%) were negative. From the 397 positive cultures, 124 (31.2%) were deemed as contaminants while 273 (68.8%) were true pathogens (Table 1). The overall contamination rate was 7.7%. Contamination rate was higher in females (8.7%, 61/702) than in males (6.9%, 63/910); although, the difference was not statistically significant (x^2=1.501, OR=0.7816, 95% CI= 0.5416-1.128, p=0.2204).

Blood culture contamination rates in different age groups and wards/units:

Blood culture contamination rates varied between children (<18 years) and adults (≥18 years), with children having lower contamination rate (7.3%, 58/800) while adults had higher rate (8.1%, 66/812). However, the difference was not statistically significant (x^2= 0.3227, OR=0.8835, 95% CI=0.6120-1.276, p=0.5700). With respect to age, age group 35-39 years had the highest contamination rate (9.0%, 16/177) while age group 5–17 years (1.6%, 3/183) had the lowest contamination rate. The difference is statistically significant (x^2=11.567, p=0.041) (Table 2).

Comparing the blood culture contamination rates of the wards/units, the female surgical ward had the highest contamination rate (11.9%, 10/84), followed by the intensive care unit (10.4%, 29/279) while the accident and emergency had the lowest contamination rate (1.3%, 1/80) (Table 3). However, the difference was not statistically significant (x^2=11.825, p=0.2970).

Table 1: Blood culture contamination rates by gender

Gender	Number of blood cultures	Number of blood culture contaminated (%)	x^2	OR (95% CI)	p value
Male	910	63 (6.9)	1.501	0.7816 (0.5416-1.128)	0.2204
Female	702	61 (8.7)			
Total	**1612**	**124 (7.7)**			

OR = Odd ratio; x^2 = Chi-square, CI = Confidence interval

Table 2: Blood culture contamination rates by age groups

Age group (years)	Number of blood cultures	Number of blood culture contaminated (%)	x^2	*p* value
<5	617	55 (8.9)		
5-17	183	3 (1.6)	11.567	0.041*
18-34	204	16 (7.8)		
35-49	177	16 (9.0)		
50-65	198	14 (7.1)		
>65	233	20 (8.6)		
Total	**1612**	**124 (7.7)**		

x^2 = Chi-square; * = statistically significant

Table 3: Blood culture contamination and total blood cultures from the various wards/units

Wards/units	Frequency of blood culture contamination (%)	Total blood cultures	x^2	*p* value
Intensive Care	29 (10.4)	279	11.825	0.2970
Female Medical	28 (8.1)	344		
Children Emergency	21 (6.3)	333		
Neonatal Intensive Care	15 (7.4)	203		
Female Surgical	10 (11.9)	84		
Male Medical	7 (6.4)	110		
Paediatrics	6 (7.4)	81		
Male Surgical	3 (8.6)	35		
General Outpatient Department	3 (8.8)	34		
Accident and Emergency	1 (1.3)	80		
Obstetrics and Gynaecology	1 (3.4)	29		
Total	**124 (7.7)**	**1612**		

x^2 = Chi-square

Table 4: Blood culture contamination rates by years

Year	Total number of blood cultures	Number of positive cultures (%)	True positive (%)	False positive (%)	x^2	*p* value
2022	480	126 (26.3)	81 (16.9)	45 (9.4)	4.246	0.2630
2021	219	62 (28.3)	42 (19.2)	20 (9.1)		
2020	493	134 (27.2)	99 (20.1)	35 (7.1)		
2019	336	62 (18.5)	42 (12.5)	20 (6.0)		
2018	84	13 (15.5)	9 (10.7)	4 (4.8)		
Total	**1612**	**397 (24.6)**	**273 (16.9)**	**124 (7.7)**		

x^2 = Chi-square

Microorganisms of blood culture contamination:

The contaminants isolated were coagulase-negative staphylococci (93.5%, n=116), *Bacillus* spp (4.0%, n=5) and *Corynebacterium* spp (2.4%, n=3).

Distribution of contamination rates by year:

The contamination rates increased progressively over the 5 years from 2018 to 2022. As shown in Table 4, the highest annual rate of blood culture contamination rate was in 2022 (9.4%) followed by 2021 (9.1%) and the lowest in 2018 (4.8%). The blood culture contamination rate increased over the 5 years, however, this increment was not statistically significant (x^2=4.246, p=0.2630).

Discussion:

Determination of blood culture contamination is critical for proper management of patients with bloodstream infections and judicious utilization of hospital resources. A decrease in blood culture contamination will reduce the unnecessary use of antimicrobial agents and their potential adverse effects such as increased risk of development of AMR, toxic side effects of the drugs, increased cost etc. In this study, the overall blood culture contamination rate was 7.7%, with the annual blood culture contamination rate increasing over the 5 years, reaching its highest level in 2022 with 9.4%, although this increase was not statistically significant. These contamination rates are above the global benchmark of <3% (11). Contamination rates reported in the literature vary between institutions, ranging from 0.9%-56% (9, 12). The rate observed in our study is lower than that reported in a previous study in north-central Nigeria (8).

The high rate in our study could be attributed to inadequate aseptic practices such as not waiting for the recommended contact or drying time of the antiseptic solution, re-palpation of the disinfected area before phlebotomy and the use of non-dedicated phlebotomists. Blood culture contamination has been linked to several factors including improper aseptic techniques used when collecting blood, especially by poorly trained staff. Studies have also reported that the use of dedicated phlebotomists with competency training and assessment focu-

sed on aseptic techniques is associated with a reduction in the blood culture contamination rate (4,13,14). Some recommendations to achieve a low rate of blood culture contamination should be followed, including the use of well-trained and dedicated phlebotomists and use of effective antiseptic agents and adherence to the protocol on standard collection and aseptic techniques (6,15). There will also be a need for regular calculation and analysis of the blood culture contamination rate to maintain a low rate. The observed progressive increase in contamination rate over the 5-year period may be attributable to rapid staff turnover, lack of ongoing training in the teaching hospital setting and blood culture contamination rate not being a targeted performance indicator in our institution.

The age group 35-49 years had the highest contamination rate (9.0%). This is contrary to the observation in other studies, which reported that the highest rate of contamination was among patients <5 years old and the elderly (1,4,15). Determination of the department with the highest rate of blood culture contamination is essential in reducing the rate of blood culture contamination. The female surgical ward (11.9%) had the highest contamination rate in our study. This is similar to studies conducted in Saudi Arabia and South Africa which reported the highest contamination rates in the surgical units (1,16). Other studies have reported the highest rate of contamination in the emergency and dialysis units (3,4,7). We are not able to speculate on the possible reasons for high rate of contamination in the female surgical ward due to the retrospective nature of our study as well as inability to examine possible factors that may contribute to this observation. The intensive care unit (10.4%) accounted for the second-highest rate of contamination. The high rate observed in the intensive care unit might be attributable to the critical condition of the patients, who may be hypovolemic or hypotensive thereby resulting in multiple needle sticks to obtain blood from fragile and less prominent veins. A study in the United States reported admission into intensive care unit as a risk factor for blood culture contamination (2).

Coagulase-negative staphylococci were the most common contaminant observed in this study, which is similar to reports of other studies (1,4,6,8,15). *Bacillus* spp and *Corynebacterium* spp were other contaminants observed in this study which is similar to other studies. The microorganisms observed in this study are normal skin microbiota indicating that contamination occurred during the process of specimen collection. Other studies have reported *Micrococcus*, viridians group of streptococci and *Propionibacterium* spp as possible blood culture contaminants (3,4,7).

There are some limitations in this study. Firstly, only one blood culture sample was used in the study which may not be sufficient to differentiate contaminants from true pathogens in some cases. Repeated isolation of the same organism in different blood culture bottles from a patient supports the organism as being a true pathogen as some studies have reported CoNS as true pathogens in bloodstream infections especially in children and patients on intravenous catheters if repeatedly isolated in different blood culture bottles or isolated from blood and primary focus. Secondly, the retrospective nature of our study limits the ability to examine possible factors responsible for contamination and to provide outcome data. A prospective study is preferred.

Conclusion:

The overall blood culture contamination rate of 7.7% in this study is higher than <3% recommended and all the contaminants were normal skin flora. There is the need to adopt multi-dimensional strategies such as the establishment of disinfection policies and protocols, the use of phlebotomists, continuous monitoring and feedback to reduce blood culture contamination rate and avoid unnecessary use of antibiotics.

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Contributions of authors:

TOO, IIO and CJE conceptualized and designed the study, HNO analyzed and interpreted the data, TOO, IIO, and AOO contributed to drafting the manuscript. All authors contributed equally to the development and critical review of the manuscript, and approved the final version submitted for publication.

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Authors have no conflict of interest

Previous presentation:

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