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Do Pediatric Residents Collect Blood Culture with the Appropriate Technique?

Pediatri Asistanları Uygun Teknikle Kan Kültürü Alıyor mu?

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ABSTRACT

Introduction: *Blood culture is the "gold standard" test for detecting microorganisms in the blood. The American Society for Microbiology recommends keeping blood culture contamination rates below 3%. The study aimed to evaluate whether pediatric residents working in our hospital collect blood cultures with appropriate techniques.*

Materials and Methods: *A blood culture checklist was prepared based on national and international guidelines. The pediatric residents were asked to obtain blood cultures from a model arm. Meanwhile, they were observed by a pediatric infectious disease specialist and an infection control nurse. No intervention was made to the residents during the observation.*

Results: *A total of 70 residents were observed. It was observed that 27.1% (n= 19) of the residents provided proper hand hygiene. Povidone-iodine (80%, n= 56) was the most preferred skin antiseptic, and 70% alcohol was used as a skin antiseptic by 20% (n= 14) of the residents. Twenty two point nince percent of the residents (n= 16) waited for the appropriate time after applying alcohol or povidone-iodine. Seventeen point one percent of the residents took blood in the volume appropriate for the patient's body weight.*

Conclusion: *It was observed that residents had low compliance with the standards while taking blood culture which is a problem that has to be improved.*

Key Words: *Blood culture; Blood culture contamination; Checklist; Povidone-iodine*

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ÖZ

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Giriş: *Kan kültürü, kandaki mikroorganizmaları saptamak için "altın standart" testtir. Amerikan Mikrobiyoloji Derneği, kan kültürü kontaminasyon oranlarının %3'ün altında tutulmasını önermektedir. Bu çalışmada hastanemizde çalışan pediatri asistanlarının uygun tekniklerle kan kültürü alıp almadıklarının değerlendirilmesi amaçlanmıştır.*

Materyal ve Metod: *Ulusal ve uluslararası kılavuzlardan yararlanılarak kan kültürü kontrol listesi hazırlandı. Pediatri asistanlarından model bir koldan kan kültürü almaları istendi. Bu sırada pediyatri asistanları çocuk infeksiyon hastalıkları uzmanı ve infeksiyon kontrol hemşiresi tarafından gözlemlendiler. Gözlem sırasında asistanlara herhangi bir müdahalede bulunulmadı.*

Bulgular: *Toplam 70 asistan gözlemlendi. Asistanların %27.1 (n= 19)'inin uygun el hijyeni sağladığı görüldü. Povidon-iyot (%80, n= 56) en çok tercih edilen cilt antiseptiğiydi ve asistanların %20 (n= 14)'si cilt antiseptiği olarak %70'lik alkol kullanıyordu. Asistanların toplam %22.9'u (n= 16) alkol veya povidon-iyot kullandıktan sonra uygun süreyle bekledi. Asistanların %17.1'i hastanın vücut ağırlığına uygun hacimde kan aldı.*

Sonuç: *Asistanların kan kültürü alırken standartlara uyumlarının düşük olduğu görüldü. Bu durum iyileştirilmesi gereken bir problemdir.*

Anahtar Kelimeler: *Kan kültürü; Kan kültürü kontaminasyonu; Kontrol listesi; Povidon iyot*

INTRODUCTION

Blood cultures are critical diagnostic tools for confirming or excluding bacteremia, sepsis, suspected catheter-associated bacteremia, infective endocarditis, meningitis, arthritis, osteomyelitis, and systemic inflammatory response syndrome caused by infection. Blood cultures should be obtained in any patient with fever, hypothermia, leukocytosis, absolute granulocytopenia, or a combination of these markers[1]. Blood culture is considered the "gold standard" for detecting microorganisms in the blood[2]. A microorganism growth in the blood culture of a patient with fever guides the clinician to exclude non-infectious causes of fever. However, false-positive results or contamination could limit the utility of this important tool.

The growth of microorganisms in the blood culture, which were not present in the patient's bloodstream, is defined as contamination[3]. Contamination leads to several disadvantages, including an extended length of hospital stay, increased costs, unnecessary laboratory testing, and the development of antimicrobial resistance[4,5]. The Clinical and Laboratory Standards Institute recommends the target blood culture contamination rate to be below 3%[6]. However, blood culture contamination rates vary between 2.85% and 9.1% in the literature[7-9]. In previous studies, it was noted that the rate of contamination is higher in infants and children due to the special difficulties associated with taking blood cultures in this age group[9,10].

In prior research, the impact of various factors, including pre-blood culture skin cleaning, culture bottle preparation, blood collection from catheters or peripheral veins, the efforts of specialized phlebotomy teams, and the utilization of commercial blood culture collection kits has been examined to assess their influence on reducing rates of blood culture contamination[3]. In a pediatric hospital, the rate of blood culture contamination was reduced to 1.5% through the standardization of blood culture collection methods, optimization of blood volume, implementation of checklists, and enhancement of nurse education[7]. In another study, various

sensitivity analyses showed that the use of a sterile kit or phlebotomy team while taking blood cultures was less costly than the routine procedure[11].

This study aims to assess the appropriateness of blood culture collection techniques by pediatric residents in our hospital. Recognizing the current situation is crucial to determine the necessary measures for reducing blood culture contamination rates in our facility.

MATERIALS and METHODS

This prospective observational study was conducted at the University of Health Sciences, Dr. Behçet Uz Pediatric Diseases and Surgery Training and Research. Seventy pediatric residents who volunteered to participate were included in the study. Written informed consent was obtained from all volunteers. A checklist was prepared, outlining the steps for blood culture collection. While creating this checklist, the guidelines prepared by the South African Society of Clinical Microbiology and the Turkish Society of Clinical Microbiology Specialization were used (Table 1) [12-14]. Pediatric residents were instructed to simulate the blood culture collection procedure by sampling from a model arm, mimicking a real patient scenario. Meanwhile, they were observed by a pediatric infectious disease specialist and an infection control nurse. The steps were recorded as either "fail" or "success" on the checklist. No interventions were made with the pediatric residents during the observation. After the completion of the procedures, an evaluation meeting was conducted, and feedback and educational sessions were organized.

Statistical Analysis

The collected data were analyzed with SPSS Software version 20 (IBM Corporation, Armonk, NY, USA). For continuous variables such as age, descriptive statistics including either mean and standard deviation or median and minimum-maximum values were reported based on the distribution of data. The frequency of "failed" or "successful" steps during blood culture procedures was presented as a percentage. A p-value of <0.05 was considered significant.

Ethics approval

This study was approved by the Ethics Committee of the University of Health Sciences Dr. Behçet Uz Pediatric Diseases and Surgery Training and Research Hospital (Protocol serial number: 690, date: 21/04/2022).

RESULTS

A total of 70 pediatric residents were observed while collecting blood culture samples from a model arm. The median duration of their occupational experience was 18 months, ranging from six months to four years. The gender distribution revealed that 24.3% (n= 17) were male, while 75.7% (n= 53) were female. Among the residents, 90% (n= 63) failed to check all the materials required for blood sampling. Furthermore, 77.1% (n= 54) did not verify the patients' identity, whereas 22.9% (n= 16) followed the procedures for verification (Table 1). It was observed that 27.1% (n= 19) of the residents practiced appropriate hand hygiene, and 60% of them (n= 42) wore sterile gloves.

Only four residents strictly adhered to the skin disinfection steps outlined in the checklist. The specifics of observed deviations in skin disinfection steps are detailed in Table 2. When providing skin disinfection, 55.7% of the residents (n= 39) appropriately used sterile gauze, while 44.3% of the residents (n= 31) opted for non-sterile cotton. Povidone-iodine (80%, n= 56) emerged as the most preferred skin antiseptic for the sampling site, while 20% (n= 14) of pediatric residents opted for 70% alcohol as a skin antiseptic. Of the residents, 22.9% (n= 16) waited for an appropriate time after applying alcohol or povidone-iodine on the skin, while 77.1% (n= 54) did not wait for the necessary drying time before collecting a blood culture.

Only 17.1% of the residents (n= 12) were aware of the appropriate volume to be taken based on the patient's body weight, while 75% of the residents (n= 52) did not consider the patient's body weight when collecting blood cultures. Considering that a single failure could lead to injector contamination, we calculated the overall failure rate. All blood sampling procedures exhibited failures that are likely to result in

Table 1. Blood culture checklist, and compliance rates of the pediatric residents

Blood Culture Checklist[12-14]	The number of residents recorded as "successful" n (%)	Number of residents recorded as "failed" n (%)
1. Assemble the correct materials required for blood culture: tourniquet, unsterile gloves, sterile pack containing gauze swabs, sterile gloves, 70% alcohol solution, syringe (20 mL), needle (22 gauge or more), blood culture bottle(s), sharps waste disposal bin, patient labels.	7 (10)	63 (90)
2. Verify the patient's identity: Ask the patient for their name. Check the armband. Inform the patient of your intentions and explain the procedure.	16 (22.9)	54 (77.1)
3. Check the bottle: Expiry date, physical damage (cracked, broken, missing cap, etc.), bottle contents (turbidity, missing volume, etc.)	3 (4.3)	67 (95.7)
4. Stick barcodes on bottles.	46 (65.7)	24 (34.3)
5. Mark the amount of blood to be drawn on the bottle.	3 (4.3)	67 (95.7)
6. Clean hands using correct hand hygiene techniques. Wash hands with soap and water or disinfect with alcohol hand disinfectant. Dry your hands or rub the hand disinfectant in until dry.	19 (27.1)	51 (72.9)
7. Apply non-sterile gloves.	61 (87.1)	9 (12.9)
8. Apply tourniquet.	57 (81.4)	13 (18.6)
9. Select the appropriate vein.	69 (98.9)	1 (1.4)
10. Untie the tourniquet.	0 (0)	70 (100)
11. Provide proper skin disinfection: Clean skin with 70% isopropyl alcohol sterile gauze for at least 30 seconds and allow to dry for 30 seconds. Repeat.	4 (5.7)*	66 (94.3)*
12. After removing the protective cap on the top of the bottle, disinfect the rubber part with sterile gauze with 70% alcohol.	28 (40)	42 (60)
13. Prepare the syringe or blood collection set.	70 (100)	0 (0)
14. Remove the non-sterile gloves.	35 (50)	35 (50)
15. Tighten the tourniquet again.	0 (0)	70 (100)
16. Clean hands using the correct hand hygiene technique again.	1 (1.4)	69 (98.6)
17. Apply sterile gloves	42 (60)	28 (40)
18. Take the appropriate volume of blood for the age and weight of the patient.	12 (17.1)	58 (82.9)
19. Untie the tourniquet.	37 (52.9)	33 (47.1)
20. Remove needle and syringe from the puncture site.	70 (100)	0 (0)
21. Place dry swab on puncture site and apply pressure. Control the bleeding.	60 (85.7)	10 (14.3)
22. Add appropriate volume of blood into the blood culture bottle. If blood was taken with an injector, inoculate the blood culture bottles before other test tubes.	63 (90)	7 (10)
23. Throw the injector or vacuum system penetrator into the waste bin.	69 (98.6)	1 (1.4)
24. Gently rotate the blood culture bottle to mix the blood and culture medium (do not shake vigorously).	31 (44.3)	39 (55.7)
25. Deliver the blood culture bottle to the laboratory as soon as possible within two hours at the latest. If there is a delay in delivering the sample to the laboratory, avoid refrigerating the bottle; instead, leave it at room temperature.	Not available	Not available

*Details on skin disinfection are given in Table 2.

Table 2. Preferences of pediatric residents' for skin disinfection

	n (%)
Using sterile gauze when disinfecting the skin	39 (55.7)
Using non-sterile cotton when disinfecting the skin	31 (44.3)
Preferring povidone-iodine as a skin antiseptic	56 (80)
Preferring alcohol 70% as a skin antiseptic	14 (20)
Waiting for an appropriate time after applying skin antiseptic	54 (77.1)

culture contamination.

DISCUSSION

Our study found that the compliance of pediatric residents with the standards for blood culture sampling in our hospital, including basic steps such as hand hygiene and skin preparation, was low. This is the first observational study conducted in Türkiye and provides insights into potential improvements for the future.

The procedure of blood culture collection encompasses several steps, including hand hygiene, skin disinfection, preparation of blood culture bottles, blood collection, and handling of samples in the laboratory. Contaminated blood cultures can result from improper practices at any of these steps[3]. Likewise, the current study also highlights numerous errors observed in each step of the checklist, with variations in their frequencies.

Effective hand hygiene, whether using soap and water or an alcohol-based hand disinfectant, is fundamental in infection prevention practices. Per the recommendations from the Centers for Disease Control and Prevention, healthcare personnel should decontaminate their hands before direct contact with patients and after contact with a patient's intact skin[15]. Alcohol-based hand rubs are the most effective agents for reducing the number of bacteria on the hands of personnel. Therefore, alcohol-based hand rubs are recommended for routine decontamination of hands for all clinical indications (except when hands are visibly soiled)[15]. Nevertheless, a prior systematic review indicated that the mean hand hygiene compliance was 59.6%[16]. In this study, despite not reflecting the actual data on patient care, a total of 27.1% of the pediatric residents demonstrated proper hand hygiene. Ensuring proper hand hygiene before blood culture collection lowers the risk of introducing contaminant bacteria into blood culture bottles[17].

One prevalent mistake to avoid during blood culture collection, as emphasized in our study, is the failure to allow antiseptic solutions to dry for the required duration[7]. A total of 77.1% of pediatric residents did not wait for the antiseptic to dry during the skin preparation step, with povidone-iodine being the most preferred antiseptic solution. Povidone-iodine is an antiseptic with a relatively slower onset of action compared to alcohol or chlorhexidine[18]. Povidone-iodine preparations require 1.5 to two minutes of contact time to produce their maximum antiseptic effect[19]. In a randomized controlled trial, chlorhexidine-gluconate used as an antiseptic before blood culture collection was associated with significantly lower contamination rates compared with a standard povidone-iodine preparation[20]. Furthermore, the usage of chlorhexidine-alcohol for skin antisepsis provides greater protection against short-term catheter-associated infections than does povidone-iodine-alcohol[21].

Another common mistake observed was that the blood volume collected into the blood culture bottle was insufficient based on the patient's weight[7]. In this study, only 17.1% of all pediatric residents collected the appropriate volume of blood based on the patient's body weight, while 75% of pediatric residents did not take the patient's body weight into account. Collecting the appropriate volume of blood is a crucial factor in increasing the yield of true pathogens. The probability of detecting pathogens

increases with the volume of collected blood[17]. Furthermore, a retrospective study of infants and children reported that the rate of contamination was higher with lower blood volumes[22]. To minimize errors in this step, suggested blood culture volumes based on the weight of pediatric patients should be made readily available to healthcare personnel performing blood cultures.

A previous study that evaluated hospital charges for patients with negative, false-positive, and true-positive blood culture results, reported a median of $8720 as additional charges per contamination event[17]. Contaminated blood cultures are a common problem in healthcare institutions leading to considerable financial expense and clinical adverse consequences. To solve this problem, hospitals should optimize best practices in the collection, handling, and management of blood culture specimens[17]. Various methods have been employed to reduce blood culture contaminants such as forming a phlebotomy team, following a checklist, and using an initial specimen diversion device[23-26]. These methods have proven to be cost-effective. In healthcare settings where forming phlebotomy teams is not feasible, it is advisable to create bundles for blood sampling, including packaged forms such as blood culture kits.

It is essential to acknowledge limitations when interpreting the results. This study is grounded in the observations of pediatric residents performing blood cultures on a model arm, which may not precisely mirror real-life scenarios. In actual patient care, compliance with certain steps, such as verifying the patient's identity, could be better maintained.

In conclusion, hospitals aiming to reduce blood culture contamination rates should first pinpoint common flaws in established practices. Subsequently, the implementation of evidence-based quality improvement strategies becomes essential to minimize blood culture contamination. For healthcare settings where forming phlebotomy teams is impractical, the introduction of bundles for blood sampling and packaged blood culture kits with all necessary items should be considered.

ETHICS COMMITTEE APPROVAL

This study was approved by the SBÜ İzmir Dr. Behçet Uz Pediatric Diseases and Surgery Training and Research Hospital Clinical Research Ethics Committee (Decision no: 690, Date: 21.04.2022).

CONFLICT of INTEREST

The authors have no conflicts of interest to declare that are relevant to the content of this article.

AUTHORSHIP CONTRIBUTIONS

Concept and Design: İD, NB, EK

Analysis/Interpretation: İD, NB, EK

Data Collection or Processing: All of authors

Writing: EK

Review and Correction: All of authors

Final Approval: All of authors

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