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Compliance with Blood Volumes Collected for Blood Cultures between Physicians and Phlebotomists

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Background: Blood culture is essential for the diagnosis and management of bloodstream infections. Blood volume is a key parameter determining the success of blood cultures. Studies comparing compliance between physicians and phlebotomists regarding optimal blood culture procedure are very rare in Korea.
Methods: After educating physicians (interns) and phlebotomists about the correct procedure for blood culturing, the blood volumes of forty-three percent of randomly selected aerobic and anaerobic culture sets for adult patients (≥18 years old) were compared between these two groups over a period of three months. Physicians obtained blood from all admitted patients except those in the emergency department, where phlebotomists performed blood collection.
Results: The numbers of blood culture sets requested during the study period were 3,238 and 2,136 for the physician and phlebotomist groups, respectively. The blood volumes of blood culture sets were significantly higher for the phlebotomists (16.7 mL) than for the physicians (9.2 mL). The positive rate of blood culture was also higher for the phlebotomist group (10.3% vs. 7.9%). The contamination rates (0.8%) were the same for both groups.
Conclusion: Although the patients' medical conditions, antibiotics prescriptions, or duration of hospitalization may have affected the positive rate of blood cultures, this rate might also have been influenced by the blood volume. The compliance of phlebotomists was greater than that of physicians regarding the blood volume collected for blood cultures. **(Ann Clin Microbiol 2013;16:81-86)**

Key Words: Blood culture, Bloodstream infection, Blood volume, Compliance, Quality improvement

INTRODUCTION

The mortality rate for sepsis ranges between 10-50% depending on the severity of the medical condition and the early proper treatment [1,2]. Blood culture is an essential test for the diagnosis of sepsis. Adherence to the proper procedure for blood cultures, such as the use of aseptic technique with skin decontamination and collecting a sufficient blood volume, cannot be overemphasized. Contamination of blood cultures by skin flora may result in a longer duration of hospitalization, unnecessary treatment with antibiotics, and an increase in medical costs [3-5]. Another important parameter is the blood volume. The rate of positive cultures is known to be associated with the blood volume used in the blood culture procedure [1,6]. The concentration of bacteria in the blood is known to be low (often <1 colony forming unit/mL) in adult septic patients [7]. Although the recommended blood volume for each set is 20-30 mL for adults [6,8], many hospitals in Korea have not adopted this protocol [9]. It may be difficult to draw a sufficient amount of blood from chronically ill patients who have been hospitalized for a long time. The collection of an adequate amount of blood in an aseptic manner cannot be overlooked and is an important factor determining the quality of blood cultures. Although it is very hard to generalize, it might be more difficult to educate physicians (interns) than phlebotomists. It may be difficult to educate physicians due to their busy schedules. Efficacy or educational response was investigated by measuring the blood volumes collected for blood culture by these two groups after education. Other parameters such as the positive rate and the rate of contamination with normal skin flora were also compared.

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MATERIALS AND METHODS

1. Setting

The hospital is a university-affiliated acute care institution that houses a cancer center (113 beds), medical intensive care units (19 beds), surgical intensive care units (14 beds), general wards (700 beds), and an emergency department (46 beds). This hospital is the only tertiary hospital in the region. The physicians (interns) took blood samples in all departments except the emergency department where phlebotomists (medical technicians) performed blood culture. There were approximately 25 interns and 12 phlebotomists working at the hospital during the study period. The study population included only adult patients (≥18 years old) who had been requested for blood culture from November, 2011 through January, 2012.

2. Education

The authors educated the physician group and the phlebotomist group using the same materials prior to initiating this study. The required blood volume (20 mL/set) was stressed during the education session. The recommended blood volume was 10 mL for a set of blood cultures before this study. The education consisted of slide-based lectures, face-to-face interviews, and a brochure. They were noticed to measure blood volume. The volumes of bottles were determined when the samples arrived at the department of laboratory medicine. There was no feedback regarding the blood volume or the contamination rate during the study because we wanted to observe the levels of compliance of these two groups. Because the interns' term finishes in February, we terminated the study in January.

3. Skin disinfection and blood collection

Chlorhexidine-alcohol (0.5%) was used for skin and bottle cap disinfection. The aseptic technique, involving thorough rubbing the skin and wearing the gloves, was emphasized to reduce contamination with skin flora. Blood was taken after 30 seconds or after the chlorhexidine-alcohol had completely dried. The blood was equally divided into aerobic and anaerobic bottles (one set). Two sets of blood culture were requested in most of the cases. Over a period of 3 months, the weight of each set was measured using a scale. The weights were converted into blood volumes based on the density of blood (1.055 g/dL) [10]. Not all bottles were weighed. Forty-three percent of the blood culture sets were arbitrarily chosen from each group for measurement of the volume.

4. Blood culture procedure

Standard aerobic and anaerobic bottles (bioMerieux Inc., Durham, NC, USA) were used for blood cultures. All bottles were transferred to the laboratory within 2 hours. Each bottle was inserted to the BacT/Alert 3D system (bioMerieux Inc.) as early as possible, although they were stored at 37°C during the night shift (6 PM to 9 AM). Any bottle showing a positive signal in the instrument was subjected to Gram staining and culturing. Pure colonies were identified and tested for drug susceptibility by using the Vitek 2 system (bioMerieux Inc.).

5. Definition of the positive rate and contamination rate

Any set of cultures in which the growth of any microorganism in the aerobic or anaerobic bottle was observed was scored as positive. *Bacillus* spp., *Propionibacterium acnes*, and *Micrococcus* spp. were always regarded as contaminants. *Staphylococcus epidermidis*, other coagulase negative staphylococci (CoNS), and viridans group streptococci (VGS) were classified as contaminants when only one bottle or one set out of two sets grew these organisms. The proportion of these contaminants among the requested blood cultures was defined as the contamination rate. The list of microorganisms and the requested number of blood cultures were obtained from the electronic medical records system.

6. Statistical analysis

Statistical significance was evaluated for the blood volume collected, the positive rate, and the contamination rate between physicians and phlebotomists using the paired t-test and the χ^2 test using SPSS, version 17. A P value<0.05 indicated statistical significance.

RESULTS

1. Blood volume

The numbers of blood culture sets for which the blood volume was measured were 1,398 and 912 for the physician and phlebotomist groups, respectively. The average blood volumes (±SD) of the physician group (9.2±5.9 mL) and phlebotomist group (16.7±5.5 mL) were significantly different ($P<0.05$). Over a period of 3 months, the blood volume gradually decreased from 11.2 mL to 7.9 mL for the physician group, whereas it increased slightly from 15.7 mL to 16.9 mL for the phlebotomist group (Table 1).

Table 1. Blood volume of each set of blood culture between physicians and phlebotomists*

Period	Physicians		Phlebotomists	
	N	Volume	N	Volume
November, 2011	498	11.2 (5.9)	336	15.7 (5.4)
December, 2011	320	8.2 (5.9)	170	15.5 (5.3)
January, 2012	580	7.9 (4.8)	406	16.9 (4.9)

*Each set consists of aerobic and anaerobic bottle. Value implies mean (SD) blood volume (mL).

Table 2. The blood volumes collected for blood cultures, the positive rate, and the contamination rate for physicians and phlebotomists*

	Physicians	Phlebotomists	*P* value
Blood volume (Mean±SD)	9.2±5.9 mL	16.7±5.5 mL	<0.001
Positive rate	7.9%	10.3%	<0.001
Contamination rate	0.8%	0.8%	0.878

*The numbers of blood culture sets for which the blood volume was measured were 1,398 and 912 for the physician and phlebotomist groups, respectively, whereas the numbers of blood culture sets used to determine the positive rate and the contamination rate were 3,238 and 2,136, respectively.

Table 3. Frequency of isolates of blood culture between physician group (wards) and phlebotomist group (emergency department)

Isolates	Wards (N=255)	Emergency department (N=219)	*P* value
Gram positives			
Staphylococcus aureus	33	24	0.572
Staphylococcus epidermidis	33	6	<0.001
Other CoNS	25	19	
Enterococcus spp.	13	12	1.000
Streptococcus pneumoniae	2	8	0.05
Gram negatives			
Eschericia coli	25	77	<0.001
Klebsiella pneumoniae	27	24	1.000
Acinetobacter baumannii	33	7	<0.001
Enterobacter spp.	15	5	0.066
Pseudomonas aeruginosa	11	4	0.187
Other bacteria	24	32	0.088
Candida spp.	14	1	<0.001

Abbreviation: CoNS, coagulase-negative staphylococci.

2. Positive rate and contamination rate

The numbers of blood culture sets requested during the study period were 3,238 and 2,136 for the physician and phlebotomist groups, respectively. The positive rate (10.3%) for the phlebotomist group was significantly higher than that (7.9%) of the physician group ($P<0.05$) (Table 2). *S. epidermidis*, *Acinetobacter baumannii*, and *Candida* spp. were significantly more commonly isolated from the ward, whereas *Eschericia coli* was most common (35.2%) among the isolates of emergency department ($P<0.001$) (Table 3).

The contamination rates of the two groups were the same, at 0.8%. There were 26 contaminants (11 *S. epidermidis*, 13 other CoNS, 2 VGS) in the physician group and 18 contaminants (4 *S. epidermidis*, 7 other CoNS, 3 VGS, 2 *P. acnes*, 1 *Bacillus* spp. and 1 *Micrococcus* spp.) in the phlebotomist group.

DISCUSSION

Blood volume is a key parameter in blood cultures. However, the volume collected is often far less than that mandated by the standard guidelines (20-30 mL per set). Multi-center surveys have revealed that the average blood volume per set was 7.3 mL in Korea [11] and 10 mL in the USA [12]. Many clinicians are not aware of the significant influence of the blood volume on the detection of bacteremia or fungemia [10]. Medical students, the future physicians and surgeons, are sometimes taught incorrect procedures for blood culturing. The optimal timing of blood cultures, the number of blood cultures for each episode, and the blood volume for each venipuncture are important parameters that influence the outcome of blood cultures [1,5,8]. Thorough skin disinfection and aseptic blood collection procedures should be emphasized during the education of medical personnel. Other issues, such as follow-up cultures, the isolation of fastidious microorganisms or mycobacteria, the use of resin- or charcoal-based media to absorb the antibiotics prescribed prior to blood collection, and catheter-related infections, should be further considered to maintain the high quality of blood cultures [1,8]. Periodic statistical analysis of the positive rate, the contamination rate, or the blood volume of each set may enable the quality of blood culture at an institution to be improved [1]. Although we did not provide the laboratory data to the medical personnel, a study reported that providing feedback to phlebotomists reduced the contamination rate from 2.6% to 1.4% [13].

CLSI recommends the following blood culture parameters: positive rate, 6-12%; contamination rate, ≤3%; and blood volume of each set, 20-30 mL [8]. The positive rate and the contamination rate of our data meet the CLSI guidelines. Compliance with the recommended blood volume (20-30 mL) was difficult to maintain. The collection of a large volume might require technical skill.

Strict adherence to the protocol appeared to be weaker in the

physician group because the average blood volume was 11.2 mL in the first month, 8.2 mL in the second month, and 7.9 mL in the third month. However, the blood volume remained steady (15.7 mL, 15.5 mL, and 16.9 mL for the three months) in the phlebotomist group. The physicians might have a tight schedule to maintain, or they might be distracted by other activities in the ward, drawing focus away from the proper procedure for blood culturing. In addition, the appropriate amount of blood could not be collected from some admitted patients. The physician group might also be less skilled in venipuncture.

The positive rate of each group seemed to be associated with the blood volume of each set (10.3%/16.7 mL in the phlebotomist group vs. 7.9%/9.2 mL in the physician group). Although many factors, such as disease severity, length of hospitalization, exposure to antibiotics, and immune status of the patient, might have affected the positive rate, the blood volume collected for the blood culture might partly contribute to the positive rate. Although the study groups are different, the previous data for the blood volume, positive rate, and contamination rate were 7.8 mL, 8.8% and 2.8%, respectively, for the physician group in our institution [11]. Quality improvement was noted with respect to the contamination rate, but no substantial improvement in the blood volume or positive rate was observed. Although we cannot explain the lower contamination rate compared with the past (2.8% in 2009 to 0.8% in this study), the education of medical personnel might have played a role. The disinfectant used for skin preparation was recently changed from 10% povidone-iodine to 0.5% chlorhexidine-alcohol. An analysis of the effect of this change in the disinfectant did not reveal a reduction in the contamination rate in another study [14]. This finding supports the hypothesis that the lower contamination rate might be due to the educational intervention rather than the change in the disinfectant. Educational interventions have been shown to reduce the blood culture contamination rate by other researchers, from 5.70% to 1.95% [15] and from 2.59% to 2.23% [16]. As expected from the composition of the patients, *E. coli* was predominant in the emergency department, whereas *A. baumannii*, *S. epidermidis*, and *Candida* spp., which are more commonly associated with nosocomial infections or catheter related sepsis, were significantly more common in the admitted patients. Frequency of *Staphylococcus aureus*, *Klebsiella pneumoniae*, or *Enterococcus* spp. was similar in the two groups.

Although there was no difference in the contamination rate between the physician group and the phlebotomist group in our study, many researchers have reported there is a difference. The role or other activities of phlebotomists might have affected to the result of contamination rate. The phlebotomists have a lot of duties, such as EKG monitoring, CPR, urinary catheterization as well as sample collection in the emergency department in our institution. The blood cultures for decentralized patient-centered personnel, like the nurses or physicians, had significantly higher contamination rates compared with the rate for blood cultures for dedicated phlebotomy teams by the College of American Pathologists (CAP) Q-Tracks monitoring program [17]. The same organization (CAP) reported previously that the median adult inpatient blood culture contamination rate was 2.5% among 640 institutions [12]. The contamination rates of blood cultures collected by phlebotomists were significantly lower than the rates for blood cultures obtained by nonphlebotomists in the emergency department (3.1% vs. 7.4%) [4]. Introduction of a dedicated blood culture team significantly reduced the blood culture contamination rate in the other studies [5,18,19]. These reports concluded that the institution of a phlebotomy team could be cost effective, considering the enormous medical cost associated with the management of blood culture contaminants [3,4,18]. In Korea, physicians (interns) take blood samples for blood cultures in many teaching hospitals. Running a dedicated phlebotomists team for blood cultures is very rare in our country. Given that a new resident training system omitting the intern course will be implemented in the near future in Korea, a highly dedicated phlebotomist team should be considered as an alternative option to improve the quality of blood cultures.

In conclusion, the blood volume collected for culturing was significantly different between the physician group and the phlebotomist group. Although the patients' condition might be different between the two groups, compliance might have contributed to the difference in the blood volume collected for blood cultures. The positive rate seemed to be affected by the blood volume of each group. The contamination rate was lower for both groups than it had been in the past, and this decrease might be due to the educational intervention. The adequate education of medical personnel was found to be associated with improved quality of the blood cultures, and this improved quality was more clearly observed in the phlebotomist group than in the physician group.

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=국문초록=

혈액배양에서 인턴과 채혈사 간의 채혈량 순응도

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배경: 혈액배양은 혈류감염을 진단하고 치료하는데 필수적이다. 채혈량은 혈액배양에서 가장 중요한 지표이다. 한국에서 인턴과 채혈사간에 채혈과정에 관한 순응도에 관한 연구는 매우 드물다.

방법: 인턴과 채혈사에게 혈액배양에 관한 교육을 진행한 후, 3개월간 성인에서 채혈된 혈액배양 검체의 43%에 대해 채혈량을 측정하여 비교하였다. 인턴은 병실에서 채혈하였고, 채혈사는 응급실에서 채혈하였다.

결과: 연구기간 동안 인턴은 3,238건, 채혈사는 2,136건을 채혈하였다. 평균 채혈량은 채혈사 16.7 mL, 인턴 9.2 mL로서 유의한 차이가 있었다. 배양 양성률은 채혈사 10.3%, 인턴 7.9%로서 유의한 차이가 있었고, 오염률은 두 군 모두 0.8%로 동일하였다.

결론: 대상 환자 질환, 항균제 처방, 입원 기간 등이 주로 양성률에 영향을 미쳤겠지만, 채혈량도 부분적으로 양성률 차이에 기여했을 것으로 판단된다. 인턴보다 채혈사에서 유의하게 혈액배양 채혈량의 순응도가 높았다. [Ann Clin Microbiol 2013;16:81-86]

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