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Can the main infectious laboratory data estimate blood culture positivity in the emergency department

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ABSTRACT

Aims: The aim of this study was to predict the positivity of patients admitted to the emergency department with blood cultures according to laboratory results.

Method: Patients admitted to a university emergency department in the previous year with blood cultures were retrospectively analysed, and laboratory and vital signs were compared with blood culture positivity.

Results: Retrospective analysis of patients whose blood cultures were obtained in the emergency department showed that increases in C-reactive protein (CRP) and procalcitonin (PCT), which are acute phase reactants, correlated with blood culture positivity. In addition, the increase in fever, which is one of the vital signs, was also correlated with blood culture positivity. When the laboratory values in our study were analysed, it was found that blood culture was positive when the CRP value was 171.15 ± 121.344 mg/L, and the PCT value was 14.30 ± 25.910 µg/L.

Conclusion: As a result of our study, we found that blood culture positivity can be poorly predicted in patients with high CRP and PCT who present to the emergency department, especially due to infection findings.

Keywords: Blood culture, C-reactive protein, procalcitonin, septicaemia, white blood cell

INTRODUCTION

The identification of the microorganism responsible for bloodstream infections is of paramount importance in emergency departments, where the urgency of such cases requires prompt diagnosis and treatment [1-2]. Lung infections, osteomyelitis, deep skin infections, endocarditis, catheter-related infections, primary bacteremia, severe abscess, osteomyelitis, cellulitis, abdominal cavity infections, and urinary tract infections are the main causes of bloodstream infections [3-6]. In particular, in cases of sepsis or critical illness, the speed of diagnosis and the efficacy of antimicrobial treatment are of paramount importance in determining the ultimate outcome for the patient [7-9].

In cases where there is a clinical indication, blood cultures should be obtained prior to the commencement of antimicrobial therapy. The presence of contaminants in blood cultures has the potential to have adverse effects on the patient, the healthcare organisation and antimicrobial stewardship efforts. These effects may include the administration of unnecessary antibiotics and an extended length of stay. Bates et al. determined that the contamination of the blood cultures increase 20% of the laboratory and 39% intravenous antibiotics costs. Also the hospitalisation time had been increased to 4.5 days [10].

In a study conducted by Skoglund and colleagues, it was observed that the mean duration of hospitalisation was 2 days longer in patients with contaminated blood cultures compared to those with negative cultures. The same study revealed that the direct and indirect hospital costs associated with a contaminated blood culture were

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$12,824, in comparison to $8,286 for a negative blood culture. This equates to a cost saving of $4,538 for each instance of a contaminated blood culture that was prevented [11].

A variety of criteria have been proposed with the aim of increasing the positivity rate in blood cultures. It has been recommended that blood culture samples should be obtained from patients with a score of 2 or above according to the modified Shapiro criteria [12].

G.R. Jones and J.A. Lowes established that 61/64 (95%) of patients who met SIRS criteria had a positive blood culture [13].

In the literature, the diagnostic values of PCT with C-reactive protein (CRP), erythrocytes sedimentation rate (ESR), white blood cell (WBC) count are compared according to the blood culture in patients with bacterial blood infections [14].

The objective of this study is to ascertain if there are threshold values for laboratory parameters that can inform the determination of the blood culture positivity rate in patients presenting to the emergency department. This will facilitate the reduction of the negativity rate and economic costs by preventing unnecessary blood culture requests.

METHODS

In this study, we analysed the blood culture results of 250 patients who presented to the emergency department between 01.01.2024 and 31.01.2024 with suspected infection and had blood culture samples taken. Our patient population consisted of individuals aged 18 years and older. Electronic medical records containing all medical and nursing notes were evaluated, and the fever value measured by emergency department nurses and the white blood cell (WBC), C-reactive protein (CRP), and neutrophil count obtained from the patient's tests were recorded. For the statistical analysis, fever values above 38°C were accepted according to the clinical definition of the Centres for Disease Control and Prevention. I also reviewed the observation charts of eligible patients.

The Methodology Employed in The Collection of Blood Cultures

Blood cultures in our emergency department were obtained in accordance with the established guidelines, which recommend the collection of at least two BC sets from different sites and inoculation of 8–10 mL of blood per bottle.

The Kolmogorov–Smirnov test was used to ascertain whether two distributions are statistically different, or whether an underlying probability distribution differs from a hypothesised distribution. Once a normal distribution has been established for the groups in question, the independent samples t-test is used to ascertain whether there are significant differences between the means of two samples that have been drawn from disparate groups. The chi-square test was used to determine whether the differences between the groups were statistically significant. A p-value less than 0.05 is typically considered to be statistically significant. The study was approved by the Sivas Cumhuriyet University Ethics Committee.

RESULTS

In a cross-sectional study of 250 patients admitted to the emergency department, the mean age of 97 patients with positive blood culture results was 68.82 ± 14.76 years, while the mean age of 153 patients with negative blood culture results was 73.17 ± 13.39 years. The laboratory results according to blood culture results are given in **Table 1**.

Table 1. *Mean values of the predicting laboratory factors for blood culture.*

Group Statistics				
	Blood culture	**N**	**Mean±Std. Deviation**	**p**
CRP (mg/dl)	Pozitive	97	171,15±121,344	0,002*
	Negative	153	128,15± 93,834	
WBC (10^9/L)	Pozitive	97	10,31± 7,46	0,062
	Negative	153	13,03± 12,96	
Neutrophil count (%)	Pozitive	97	78,98± 21,009	0,9
	Negative	153	78,70± 17,481	
Procalcitonin (µg/L)	Pozitive	60	14,30± 25,910	0,001*
	Negative	99	4,14±11,542	
Fever (°C)	Pozitive	97	37,10±0,845	0,002*
	Negative	153	36,78±0,715	

The patients were classified into two groups according to their admission fever and analysed with chi-square statistical analyses. There wasn't any difference between the groups according to the blood culture results (**Table 2**).

To determine the most predictive factor, we made an ROC analysis, and CRP had the highest AUC, but none of them had a high predictive value (**Figure 1**).

To determine whether blood culture results were decisive in the treatment of patients, we investigated whether significant antibiotic changes were made based on culture

Table 2. *Blood culture results according to admission fever positivity*

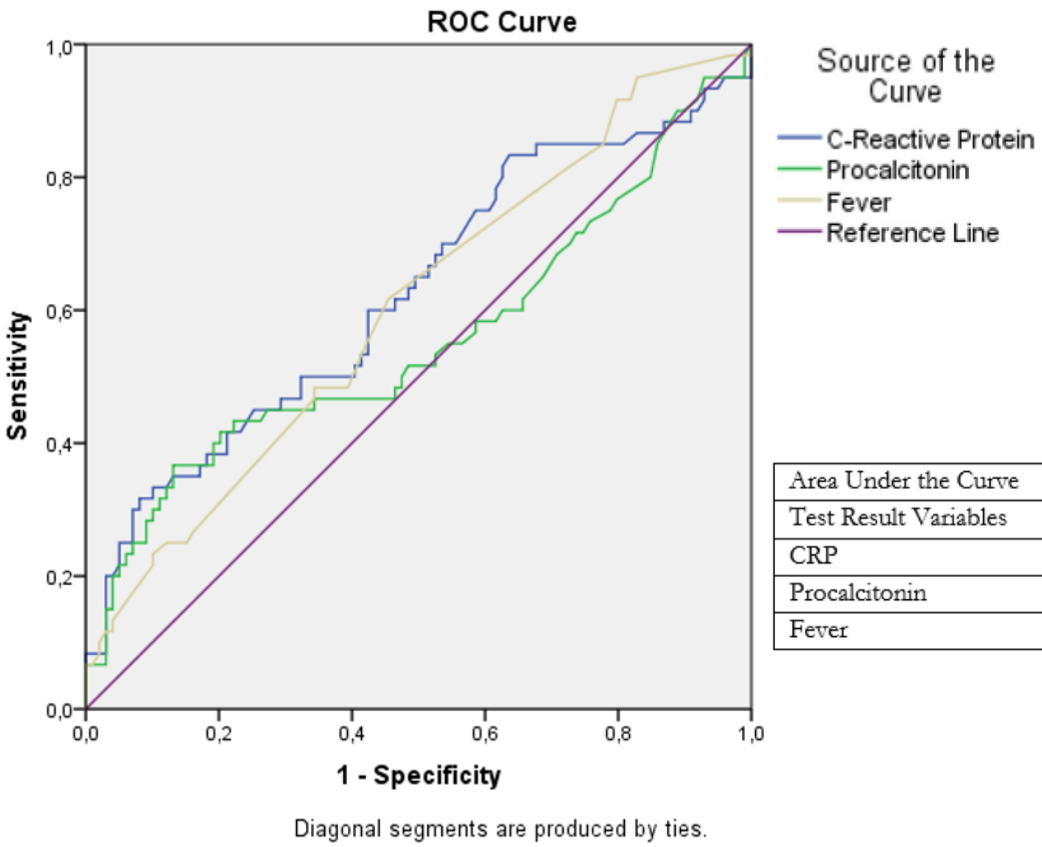
		Patients with fever (>38°C)	Patients without fever (<38°C)	p
Blood culture result	Positive	21(52,5%)	76(78,4%)	>0.05
	Negative	19(12,4%)	134(87,6%)	

χ^2 = 3.7639.

Table 3. *Determination of change in antibiotic therapy according to blood culture results*

Blood culture results	The patient cohort remains on the same antibiotic regimen.	The patient cohort undergoing a change in antibiotic therapy.	P value
Pozitive	74(75,5%)	24(24,5%)	0.09
Negative	134(88,2%)	18(11,8%)	
Total	208((83,2%)	42(16,8%)	

χ^2= 6,819



Area Under the Curve	
Test Result Variables	Area
CRP	0,625
Procalcitonin	0,566
Fever	0,604

Figure 1. *ROC analysis for determining the most predictive factor for blood culture results*

results. We didn't determine a significant change in antibiotic therapy between the positive and negative blood culture patients. (**Table 3**)

When blood culture results and antibiotic treatments of the patient in the inpatient unit were examined, drug treatment was changed in 24.5% of the patients with positive culture results, but also the antibiotic treatment in the negative blood culture group was changed in 18 patients, and there was no difference among the groups.

DISCUSSION

The Infectious Diseases Society of America recommends 2 blood culture sets from different peripheral sites in many clinical conditions [15].

In the contemporary era, emergency department admissions due to infection and sepsis have reached considerable heights. Particularly in cases of advanced infection or sepsis, the administration of early antibiotherapy has been demonstrated to result in a favourable decline in mortality and hospitalisation times. The objective of this study was to devise an effective antibiotherapy strategy for the emergency department by investigating the correlation between CRP, PCT, WBC, and fever. These acute phase reactants play a pivotal role in the diagnosis and management of infection, and their relationship to blood culture outcomes is of significant interest.

An investigation by Xia Y et al. sought to establish a correlation between CRP level and blood culture, and determined that the mean CRP level of the group with positive blood culture results was significantly higher than the group with negative blood culture results (119 (62, 220 mg/L) versus 54 (24, 80) mg/L, respectively, U = 7.791, P < 0.001) [16]. In a further study undertaken by Nasimfar et al., who evaluated 45 septic patients in a prospective case–control study, identified a statistically significant decrease in mean serum CRP levels in patients with negative blood culture results (48.94 ± 17.66 mg/L, P = 0.004). Especially, the mean serum C-reactive protein level in patients with Gram-positive blood culture was significantly higher than the patients with negative blood culture and Gram (-) positive blood culture groups (76.2 ± 7.08 mg/L) (P < 0.001)] [17]. A study by Andrea Ticinesi et al. in geriatric patients concluded that CRP level at hospitalisation is a useful tool in detecting acute infection and sepsis. Furthermore, the study determined that CRP elevation may offer valuable short-term prognostic information [18]. In the present study, a significant correlation was identified between elevated C-reactive protein levels (>171.15 ± 121.344 mg/L) and positive blood cultures. Elevated CRP levels in patients may provide valuable insights into both the likelihood of positive blood cultures and the patient's prognosis during hospitalisation.

In the present study, procalcitonin was identified as a significant acute-phase reactant. PCT is a 116 amino acid residue that was first described in 1984 by Le Moullec et al.. In the context of current clinical practice, procalcitonin has emerged as a promising new biomarker for the early detection of systemic bacterial infections. In comparison with other inflammatory biomarkers, such as C-reactive protein, PCT has a better specificity to accurately discriminate between bacterial and non-bacterial infections. Consequently, PCT assays with a specificity of 79% have been developed and utilised to more accurately determine whether a systemic inflammatory reaction is caused by a bacterial species [19].

In the study by Assicot et al. in 1993, which was one of the first studies on PCT and whose diagnostic importance was not recognised until 1993, it was shown that there was a positive correlation between high serum PCT levels and patients with positive findings for bacterial infection and sepsis (e.g. positive blood cultures). In addition, it was also shown in the same study that PCT is not elevated in viral infections and, that serum PCT levels will decrease following the administration of appropriate antibiotic treatments [20].

A plethora of studies have evaluated pct-based treatment algorithms and found them to be safe when compared to standard care. In particular, the use of PCT assays allows antibiotic therapy to be discontinued without increased morbidity and mortality. This renders PCT a potentially useful tool to prevent the emergence of antibiotic-resistant organisms while ensuring appropriate treatment for serious bacterial infections [19]. As a result of the analysis we conducted in this study, the mean PCT in patients with positive blood culture was determined as 14.30±25.910 μg/l.

In the study conducted by Ekinci titled "Is procalcitonin elevation an accurate biomarker for bacteremia in patients presenting to the emergency department?", the specificity for bacteremia was determined to be 80% in cases where the procalcitonin threshold value was ≥3.29 μg/l, and the median of these patients was measured as 5.2 μg/l (0.01-242.6) [21].

Thomas-Rüddel to evaluate the accuracy of procalcitonin serum concentrations to diagnose Gram-negative bacteremia and the association of PCT serum concentrations with more specific pathogens and the focus of infection. While the mean value of PCT in the positive blood culture group was 12.6 μg/l (3.3–41.9) and was significantly higher than the negative blood culture group($p<0.001$) [22].

Fever is a significant vital sign utilised in the assessment of patients with infectious diseases in emergency department admissions. Fever constitutes a complex physiological response initiated by infectious or aseptic stimuli and is characterised by an elevated body core temperature, defined as >38.0°C. The identification of fever facilitates the diagnosis of its underlying cause and subsequent treatment [23].

In some cases, the presence of fever may be indicative of a minor infection; however, in other cases, it may signify a more severe infection that could potentially result in sepsis. It is noteworthy that among geriatric patients, a demographic group with a high mortality rate, approximately 15% of all geriatric patients are admitted to emergency departments due to fever [24].

In a study conducted by Howard-Anderson et al., it was observed that although there is no standard guideline for the management of fever detected in hospitalised patients, the most requested and effective test is blood culture [25].

The conventional practice has been to obtain blood specimens at or around the time of a temperature elevation as a means of enhancing the likelihood of documenting bacteremia. This practice is based on the principle that the presence of organisms in the intravascular space leads to the elaboration of cytokines, which in turn causes body temperatures to rise [26]. The American College of Critical Care Medicine and Infectious Diseases Society of America Guidelines recommend that a new fever in critically ill adult patients must be investigated by drawing of 3–4 BC sets with appropriate volume within the 24 h of fever onset [27].

When the cause of fever in these patients is attributed to infection, it is of great importance to obtain blood cultures accurately and quickly in the emergency department and to start treatment after the blood culture. Foong et al. evaluated the predictors associated with the decision of blood culture ordering among hospitalised patients. Fever was one of the factors evaluated, and they determined that patients with a fever ≥39 ℃ had a 4.17 times higher blood culture positivity with a 95% confidence interval. Also, the patients with fever had a 3.48 adjusted ratio with a 95% confidence interval (CI 3.27–3.69) [28].

However, contradictory studies have been published that demonstrate that fever is not a definitive indicator of blood culture positivity. Kee et al. conducted a retrospective single-centre case-control study of 17,607 blood cultures in children. Their findings revealed that fever prior to blood culture extraction was neither sensitive nor specific for culture positivity. The timing of blood cultures in relation to fever is of negligible clinical significance. Bacteremia occurs prior to fever, yet its clinical relevance is limited [29].

In a multicentre study conducted by Riedel et al., the researchers analysed blood cultures from 1436 patients. The analysis revealed that blood cultures performed after the onset of fever had no predictive effect on the detection of bacteraemia. The researchers emphasised the importance of obtaining sufficient sample volume, performing an appropriate number of blood cultures, and using strict aseptic technique [30].

In the study by Boyles et al., the median fever in patients with positive blood cultures was 37.4 (36.4-38.5) °C [1]. This value is similar to the values in our study, and the mean fever in patients with positive blood cultures was found to be 37.10 °C ± 0.8 °C, which was statistically significantly higher than the mean fever in patients with negative blood cultures (36.8 °C ± 0.8 °C), whereas we accepted fever as 38 °C clinically, was this difference questionable. Also, when the groups were evaluated using the chi-squared test, no significant difference was found between the groups with and without fever, which is consistent with the findings of some studies in the literature.

WBC is the most commonly used measure to investigate infection. However, it is also the least useful. Septic shock can cause leukocytosis or leukopenia. Many septic patients fall between these two extremes, with normal WBC counts. For example, half of the patients admitted to the hospital with bacteremia may have normal WBC counts. It is clear that septic shock or positive blood cultures may be present even when WBC values are normal [31]. Our study definitively ruled out a significant correlation between WBC values and positive blood cultures. Seigel and colleagues conducted a study of 3,563 patients, 289 of whom (8.1%) had positive blood cultures. In 52% of patients with positive blood cultures, the WBC count was normal [32]. The course of bacterial infection is divided into four stages based on WBC count data obtained from the onset to recovery. The first stage occurs within 12 to 24 hours of the onset of bacterial infection. During this stage, the WBC count falls below the normal reference range. Neutrophils in the circulation migrate to the site of bacterial infection; however, the bone marrow has not yet begun to increase neutrophil production, and immature neutrophils have not been released into the bloodstream in response to the bacterial infection [33]. Consequently, WBC values may be normal or low in patients presenting to the emergency department in the early phase of infection.

An analysis of blood culture results and antibiotic treatments in the patient's inpatient unit revealed that, in 24.5% of cases, antibiotherapy had been altered following the results of blood cultures taken in the emergency department. While a similar study by Boyles et al. determined a 19.6% rate of alteration in the antibiotic treatment after the blood culture results, the alteration rate in Stalnikowicz et al. the study was a 6% [1-34].

Limitations

The limitations encountered during the present retrospective study were twofold. Firstly, the methodology employed in the collection of blood cultures was not subject to rigorous scrutiny, as it was not clear whether the standard techniques had been followed. Secondly, there was a paucity of data regarding the reliability of vital sign values, as it was not known whether any previous interventions had been made. Also, procalcitonin laboratory results were only recorded in 155 patients, a deficiency that may affect the statistical results.

CONCLUSION

The analysis of the data obtained in the present study indicates that elevated levels of C-reactive protein (CRP), procalcitonin, and fever in patients presenting to the emergency department with signs of infection can be indicative of positive blood cultures. Whereas ROC analysis stated that there was a poor correlation between the laboratory results and blood culture positivity. Furthermore, the findings reveal an absence of distinction between the groups in the evaluation of antibiotic changes based on culture results in the treatment of patients, thus rendering blood cultures taken in emergency services questionable.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Sivas Cumhuriyet University Ethics Committee (Date: 24.04.2025, Decision No: 2025/21).

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Financial Disclosure

The authors declared that this study has received no financial support.

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

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