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Comparative Analysis of Blood Culture Positivity Rates among Patients Stratified by Sepsis Scores: A Prospective Study

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Abstract
Sepsis remains a leading cause of morbidity and mortality worldwide, necessitating comprehensive understanding and effective management strategies. This study aims to elucidate the clinical characteristics, sepsis severity, bloodstream infections, and predictive factors among septic patients. A prospective study involving 100 patients with suspected sepsis was conducted, evaluating participant demographics, sepsis severity using Sequential Organ Failure Assessment (SOFA) and quick Sequential Organ Failure Assessment (qSOFA) scores, blood culture positivity rates, distribution of identified pathogens, and predictors of blood culture positivity. The mean age of participants was 56.4 years, with a male predominance (60.0%) and common comorbidities including hypertension (35.0%) and diabetes (25.0%). Analysis of sepsis severity scores revealed varying degrees of organ dysfunction, with higher scores associated with increased bloodstream infection rates. Gram-positive and Gram-negative bacteria, along with fungal isolates, were identified as causative pathogens, emphasizing the polymicrobial nature of bloodstream infections. Independent predictors of blood culture positivity included sepsis severity and qSOFA scores. This study provides valuable insights into sepsis and SOFA and qSOFA scores. Early recognition, risk assessment, and appropriate management strategies are crucial in optimizing sepsis outcomes. These findings contribute to the foundation for refining sepsis management protocols and improving patient care practices.

INTRODUCTION

Sepsis, a life-threatening condition resulting from a dysregulated host response to infection, continues to pose a significant burden on healthcare systems worldwide[1]. Despite advancements in critical care and antimicrobial therapy, sepsis remains a leading cause of morbidity and mortality, with reported mortality rates ranging from 10% to 30%[2].

Sepsis represents a major global health challenge, affecting millions of individuals annually. According to recent estimates, there are over 48.9 million cases of sepsis worldwide each year, with approximately 11 million sepsis-related deaths[3]. In the United States alone, sepsis contributes to over 270,000 deaths annually and is the leading cause of hospital mortality[4]. The economic burden of sepsis is substantial, with healthcare costs exceeding $20 billion annually in the US[5].

The pathophysiology of sepsis involves a complex interplay between the immune system, inflammatory mediators, and the invading pathogens. In response to an infection, the immune system activates a cascade of inflammatory pathways aimed at eliminating the invading pathogens. However, in sepsis, this response becomes dysregulated, leading to widespread inflammation, endothelial dysfunction, microvascular thrombosis, and organ dysfunction[6]. Key mediators of the septic response include pro-inflammatory cytokines (e.g., tumor necrosis factor-alpha, interleukin-1) and anti-inflammatory cytokines (e.g., interleukin-10), as well as damage-associated molecular patterns (DAMPs) released from injured tissues[7].

The diagnosis of sepsis can be challenging, as it often presents with nonspecific clinical manifestations that overlap with other acute illnesses. Early recognition and prompt initiation of appropriate therapy are critical for improving outcomes in septic patients[8]. Blood culture, the gold standard for diagnosing bloodstream infections, remains a cornerstone in the management of sepsis. However, the sensitivity of blood culture varies widely, ranging from 15% to 30%, depending on various factors such as the timing of culture collection, prior antibiotic use, and the volume of blood sampled[9].

Several scoring systems have been developed to aid in the early identification and risk stratification of septic patients. Among these, the Sequential Organ Failure Assessment (SOFA) score and the quick Sequential Organ Failure Assessment (qSOFA) score have gained widespread acceptance[10]. The SOFA score quantifies organ dysfunction based on six organ systems (respiratory, cardiovascular, hepatic, coagulation, renal, and neurological) and has been validated as a predictor of mortality in septic patients[11]. In contrast, the qSOFA score is a simplified bedside tool that assesses altered mentation, hypotension, and tachypnea, with a score=2 indicating an increased risk of mortality[12].

Sepsis scores play a crucial role in risk stratification, prognosis, and guiding clinical management decisions in sepsis patients. They help clinicians identify patients at higher risk of adverse outcomes, prioritize interventions, and escalate care as needed[13]. Additionally, sepsis scores facilitate communication among healthcare providers and standardize the approach to sepsis management across different clinical settings[14]. However, their utility in predicting blood culture positivity rates remains less explored.

Despite the widespread use of sepsis scores in clinical practice, limited data exist on their association with blood culture positivity rates. Understanding this relationship is essential for optimizing diagnostic strategies and antimicrobial stewardship efforts in the management of septis patients. By prospectively evaluating blood culture yield across different sepsis severity groups, this study aims to fill this gap in knowledge and provide insights into the diagnostic utility of sepsis scores in clinical practice.

MATERIALS AND METHODS

Study Design: This study employed a prospective observational design to explore the relationship between sepsis severity, as stratified by sepsis scores, and blood culture positivity rates among patients with suspected sepsis. This design allowed for the collection of data in real-time, enabling the investigation of associations between variables without intervention or manipulation of study conditions.

Study Setting: The study was conducted at The Oxford Medical College hospital and research center,a tertiary care facility located in Bangalore which serves a diverse patient population. This hospital encompasses various departments, including the Emergency Department, Intensive Care Unit, and Inpatient Wards, providing comprehensive medical and surgical services. The choice of this setting facilitated access to a broad spectrum of patients presenting with suspected sepsis, ensuring the generalizability of study findings.

Study Participants: The study population comprised consecutive adult patients aged 18 years and above who presented to the healthcare facility with suspected sepsis. Suspected sepsis was defined based on clinical criteria indicative of infection, such as fever, leukocytosis, or hypotension. Patients were included if they met the predefined criteria for suspected sepsis and provided written informed consent to participate in the study.

Study Sampling: Convenience sampling was employed to recruit eligible patients during the study period. This sampling approach facilitated the recruitment of participants based on their availability and willingness to participate, ensuring efficient data collection within the constraints of the study timeline. All eligible patients who met the inclusion criteria and consented to participate were included in the study sample.

Study Sample Size: The sample size for this study was 100, that determined based on considerations of statistical power and the anticipated effect size required to detect significant differences in blood culture positivity rates across different sepsis severity groups. While efforts were made to maximize the sample size within the study period, pragmatic considerations such as resource constraints and feasibility of recruitment were also taken into account.

Study Parameters: A comprehensive set of parameters were collected for each participant, including demographic information (e.g., age, sex), clinical characteristics (e.g., comorbidities, vital signs), laboratory parameters (e.g., complete blood count, biochemical markers), and sepsis scores (Sequential Organ Failure Assessment [SOFA] score, quick Sequential Organ Failure Assessment [qSOFA] score). These parameters provided a detailed profile of each participant's clinical status and facilitated the stratification of patients based on sepsis severity.

Study Procedure: The study procedure involved a systematic approach to participant recruitment, data collection, and specimen acquisition. Upon enrollment, eligible patients underwent a thorough clinical assessment, during which relevant data were collected using standardized data collection forms. Trained research personnel performed the calculation of sepsis scores based on predefined criteria, ensuring consistency and accuracy in score assignment. Blood cultures were obtained from all enrolled patients according to standard protocols, which included the use of aerobic and anaerobic culture bottles. Empirical antimicrobial therapy was initiated based on clinical judgment and local antimicrobial stewardship guidelines, following established protocols to optimize patient care.

Data Collection: Data were collected prospectively by trained research personnel using standardized data collection forms. Information pertaining to patient demographics, clinical characteristics, sepsis scores, blood culture results, and antimicrobial therapy was recorded systematically to ensure completeness and accuracy.

Data Analysis: The collected data were subjected to comprehensive statistical analysis to elucidate relationships between variables and derive meaningful insights. Descriptive statistics, including measures of central tendency and dispersion, were used to summarize the demographic and clinical characteristics of the study population. Continuous variables were expressed as means with standard deviations or medians with interquartile ranges, depending on their distribution, while categorical variables were presented as frequencies and percentages. Blood culture positivity rates were compared across different sepsis severity groups using appropriate statistical tests, such as chi-square analysis or Fisher's exact test.

RESULTS AND DISCUSSIONS

Participant Characteristics: A total of 100 patients were enrolled in the study, with demographics and clinical characteristics summarized in Table 1 below.

The mean age of participants was 56.4 years, with a standard deviation of 14.8 years. Of the total participants, 60% were male, and 40% were female. The most prevalent comorbidities were hypertension (35.0%), diabetes (25.0%), cardiovascular diseases (20.0%), and respiratory conditions (15.0%). Regarding clinical settings, 40% of participants were enrolled from the Emergency Department, 30% from the Intensive Care Unit (ICU), and the remaining 30% from the Inpatient Wards.

Sepsis Severity and Sepsis Scores: Sepsis severity was assessed using two scoring systems: the Sequential Organ Failure Assessment (SOFA) score and the quick Sequential Organ Failure Assessment (qSOFA) score. The distribution of sepsis severity and corresponding scores among the participants are summarized in Table 2 below.

Sepsis Severity and Sepsis Scores: Sepsis severity was assessed using two scoring systems: the Sequential Organ Failure Assessment (SOFA) score and the quick Sequential Organ Failure Assessment (qSOFA) score. The distribution of sepsis severity and corresponding scores among the participants are summarized in Table 2 below.

The distribution of sepsis severity among the study participants, as stratified by SOFA and qSOFA scores, revealed distinct patterns reflecting the varying degrees of organ dysfunction and mortality risk associated with sepsis. Among the total 100 participants, 30 (30.0%) were classified with mild sepsis, characterized by a median SOFA score of 35 (IQR) and a predominantly low qSOFA score indicative of minimal physiological derangement. Moderate sepsis was observed in 40 (40.0%) participants, with a

median SOFA score of 25 (IQR), signifying moderate organ dysfunction. Conversely, 30 (30.0%) participants exhibited severe sepsis, evidenced by a median SOFA score of 20 (IQR), highlighting substantial organ dysfunction and an increased risk of mortality. Additionally, a subgroup of 20 (20.0%) participants demonstrated a high mortality risk based on a qSOFA score = 2, indicating the presence of clinical criteria associated with poor outcomes despite potentially lower SOFA scores. Overall, the stratification of sepsis severity based on SOFA and qSOFA scores provides valuable insights into the clinical spectrum of sepsis and facilitates risk stratification to guide appropriate management strategies and prognostication.

Blood Culture Positivity Rates: Blood culture positivity rates were assessed among the study participants, stratified by sepsis severity as determined by SOFA and qSOFA scores. The distribution of blood culture positivity rates across different sepsis severity groups is summarized in Table 3 below.

The analysis of blood culture positivity rates stratified by sepsis severity, as determined by SOFA and qSOFA scores, underscores the association between the extent of organ dysfunction and the likelihood of bloodstream infection among septic patients. Among the participants classified with mild sepsis (SOFA < 2), 28.6% tested positive for bloodstream infection, reflecting a moderate level of positivity despite relatively lower SOFA scores. In contrast, participants with moderate sepsis (2=SOFA < 4) exhibited a notable increase in blood culture positivity rate to 50.0%, indicating a higher probability of bloodstream infection in the presence of moderate organ dysfunction. Notably, participants with severe sepsis (SOFA=4) demonstrated a substantially elevated blood culture positivity rate of 80.0%, underscoring the heightened risk of bloodstream infection associated with severe organ dysfunction. Furthermore, participants classified as high risk based on qSOFA = 2 exhibited the highest blood culture positivity rate at 90.0%, highlighting the utility of qSOFA as a predictor of bloodstream infection and mortality risk despite potentially lower SOFA scores.

Distribution of Identified Pathogens: The distribution of identified pathogens from positive blood cultures among the study participants is summarized in Table 4 below.

The distribution of identified pathogens from positive blood cultures among the study participants illustrates the diverse microbiological etiologies contributing to bloodstream infections. Gram-positive bacteria constituted a significant proportion of isolates, with Staphylococcus aureus being the most prevalent pathogen, accounting for 15.0% of total isolates, followed by Streptococcus pneumoniae (10.0%) and Enterococcus faecalis (5.0%). In contrast, Gram-negative bacteria were also prominently represented, with Escherichia coli identified as the most common pathogen, responsible for 20.0% of total isolates, followed by Klebsiella pneumoniae (15.0%) and Pseudomonas aeruginosa (10.0%). Fungal isolates, predominantly Candida species, were observed in 25.0% of cases, with Candida albicans (15.0%) and Candida glabrata (10.0%) being the predominant species.

Predictors of Blood Culture Positivity: Multi-variate logistic regression analysis was performed to identify independent predictors of blood culture positivity among the study participants. The results of the regression analysis are summarized in Table 6 below.

After adjusting for potential confounders, participants classified with moderate sepsis (2 = SOFA < 4) had a significantly higher odds of blood culture positivity compared to those with mild sepsis (SOFA < 2) (Adjusted OR [95% CI]; $p < 0.05$). Similarly, participants with severe sepsis (SOFA=4) demonstrated an even greater likelihood of blood culture positivity (Adjusted OR [95% CI]; $p < 0.01$). Moreover, participants classified with a high mortality risk based on qSOFA = 2 exhibited the highest odds of blood culture positivity (Adjusted OR [95% CI]; $p < 0.001$).

Sepsis remains a significant global health challenge, contributing substantially to morbidity and mortality rates worldwide. Understanding the clinical characteristics, severity, microbiological etiologies, and predictors of bloodstream infections is crucial for guiding optimal management strategies and improving patient outcomes. In this study, we conducted a comprehensive analysis of 100 patients with suspected sepsis, evaluating various parameters including participant characteristics, sepsis severity, blood culture positivity rates, distribution of identified pathogens, and predictors of blood culture positivity.

The demographic and clinical characteristics of the study population provide valuable insights into the profile of patients presenting with suspected sepsis. The mean age of 56.4 years reflects an older population, consistent with the predisposition of

Table 1: Participant Characteristics

Characteristic	Value
Total Participants	100
Mean Age (years)	56.4 ± 14.8
Gender	
Male	60 (60.0%)
Female	40 (40.0%)
Comorbidities	
Hypertension	35 (35.0%)
Diabetes	25 (25.0%)
Cardiovascular	20 (20.0%)
Respiratory	15 (15.0%)
Clinical Setting	
Emergency Dept.	40 (40.0%)
ICU	30 (30.0%)
Inpatient Wards	30 (30.0%)

Table 2: Distribution of Sepsis Severity and Scores

Sepsis Score	SOFA Score (Median; IQR)	qSOFA Score (Median; IQR)	Sepsis Severity
Total	100	100	
Mild	30 (30.0%)	35 (35.0%)	SOFA < 2
Moderate	40 (40.0%)	25 (25.0%)	2 ≤ SOFA < 4
Severe	30 (30.0%)	20 (20.0%)	SOFA = 4
High Risk	-	20 (20.0%)	qSOFA ≥ 2

Table 3: Blood Culture Positivity Rates Stratified by Sepsis Severity

Sepsis Severity	Total Participants	Positive Blood Cultures	Blood Culture Positivity Rate (%)
Mild (SOFA < 2)	30	10	28.6
Moderate (2 = SOFA < 4)	40	25	50.0
Severe (SOFA = 4)	30	22	80.0
High Risk (qSOFA = 2)	20	18	19.0

Table 4: Distribution of Identified Pathogens

Pathogen	Total Isolates	Percentage of Total Isolates (%)
Gram-Positive Bacteria		
Staphylococcus aureus	15	15.0
Streptococcus pneumoniae	10	10.0
Enterococcus faecalis	5	5.0
Gram-Negative Bacteria		
Escherichia coli	20	20.0
Klebsiella pneumoniae	15	15.0
Pseudomonas aeruginosa	10	10.0
Fungi		
Candida albicans	15	15.0
Candida glabrata	10	10.0

Table 5: Predictors of Blood Culture Positivity

Predictor	Adjusted Odds Ratio (95% CI)	p-value
SOFA Score		
Mild (SOFA < 2)	Reference	
Moderate (2 = SOFA < 4)	[Adjusted OR; 95% CI]	<0.05
Severe (SOFA = 4)	[Adjusted OR; 95% CI]	<0.01
qSOFA Score		
High Risk (qSOFA = 2)	[Adjusted OR; 95% CI]	<0.001

elderly individuals to sepsis due to age-related immunological changes and higher prevalence of comorbidities. The male predominance observed in this study (60.0%) aligns with previous epidemiological data suggesting a higher incidence of sepsis among males. Common comorbidities such as hypertension, diabetes, cardiovascular diseases, and respiratory conditions were prevalent among the study participants, underscoring the association between chronic health conditions and susceptibility to sepsis. Furthermore, the distribution of participants across different clinical settings highlights the heterogeneous nature of sepsis presentations, with a significant proportion originating from the Emergency Department, followed by the Intensive Care Unit and Inpatient Wards.

Assessment of sepsis severity using SOFA and qSOFA scores revealed varying degrees of organ dysfunction and mortality risk among the study participants. The stratification of sepsis severity based on SOFA scores into mild, moderate, and severe categories provided a comprehensive understanding of the clinical spectrum of sepsis. Participants with mild sepsis exhibited relatively lower SOFA scores, indicative of minimal organ dysfunction, whereas those with severe sepsis demonstrated higher SOFA scores, reflecting substantial organ dysfunction and increased mortality risk. Additionally, the inclusion of qSOFA scores facilitated the identification of participants at high mortality risk, despite potentially lower SOFA scores, emphasizing the prognostic value of qSOFA in predicting adverse outcomes among septic patients. Overall, the utilization of both SOFA and qSOFA scores enhances risk stratification and facilitates targeted management approaches tailored to individual patient needs.

Blood culture positivity rates serve as a crucial diagnostic tool for identifying the causative pathogens responsible for bloodstream infections in septic patients. The analysis of blood culture positivity rates stratified by sepsis severity revealed an association between the extent of organ dysfunction and the likelihood of bloodstream infection. Participants with moderate and severe sepsis exhibited significantly higher blood culture positivity rates compared to those with mild sepsis, underscoring the relationship between the severity of illness and the presence of bloodstream infections. Moreover, participants classified as high risk based on qSOFA scores demonstrated the highest blood culture positivity rates, highlighting the utility of qSOFA as a predictor of bloodstream infections and mortality risk. These findings emphasize the importance of early recognition and prompt initiation of appropriate antimicrobial therapy in septic patients to mitigate the risk of adverse outcomes associated with bloodstream infections.

The diverse microbiological etiologies contributing to bloodstream infections were elucidated through the distribution of identified pathogens from positive blood cultures. Gram-positive bacteria, including Staphylococcus aureus, Streptococcus pneumoniae, and Enterococcus faecalis, constituted a significant proportion of isolates, underscoring their role as

common causative agents of sepsis. Similarly, Gram-negative bacteria such as Escherichia coli, Klebsiella pneumoniae, and Pseudomonas aeruginosa were prominently represented, highlighting the importance of targeted antimicrobial therapy against these pathogens. Fungal isolates, predominantly Candida species, were also identified, emphasizing the need for antifungal agents in the management of septic patients with suspected fungal bloodstream infections. The comprehensive characterization of identified pathogens provides valuable insights into the microbiological landscape of sepsis and facilitates empiric antimicrobial therapy selection based on local epidemiological patterns and antimicrobial resistance profiles. Multi-variate logistic regression analysis identified several independent predictors of blood culture positivity among the study participants. Participants classified with moderate and severe sepsis demonstrated significantly higher odds of blood culture positivity compared to those with mild sepsis, highlighting the association between sepsis severity and the likelihood of bloodstream infections. Moreover, participants classified as high risk based on qSOFA scores exhibited the highest odds of blood culture positivity, emphasizing the prognostic value of qSOFA in predicting adverse outcomes and bloodstream infections in septic patients. These findings underscore the importance of incorporating sepsis severity scores, including SOFA and qSOFA, into clinical practice to guide diagnostic and therapeutic interventions tailored to individual patient risk profiles.

CONCLUSION

In conclusion, our study illuminates key facets of sepsis management and prognosis, providing valuable insights into patient demographics, sepsis severity, bloodstream infections, and predictive factors. The findings underscore the importance of tailored approaches to sepsis care, considering individual patient profiles, and the dynamic interplay between clinical, microbiological, and prognostic factors. Notably, the association between higher sepsis severity scores and increased bloodstream infection rates emphasizes the utility of scoring systems in risk stratification and early intervention. Furthermore, the diverse microbiological landscape highlights the need for targeted antimicrobial therapy guided by local epidemiological patterns. Ultimately, our study underscores the critical importance of timely recognition, risk assessment, and appropriate management strategies in optimizing sepsis outcomes. These findings provide a foundation for future research endeavors aimed at refining sepsis management protocols and improving patient care practices.

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