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EMBRACING AUTOMATION: ADVOCATING THE CASE FOR AUTOMATED BLOOD CULTURE SYSTEMS IN MICROBIOLOGY LABORATORIES UPTO DISTRICT LEVEL

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ABSTRACT **Introduction:** Traditional manual blood culture methods are time-consuming and up to 60% analytical & pre-analytical errors can occur. Automated blood culture systems enable earlier detection of pathogens by continuous monitoring, reducing time to detection hence improving patient outcomes. The objective of the research is to study the relevance of this system in a resource-limited setting. **Material & Methods:** This is a retrospective hospital-based study of one year duration conductedin the Department of Microbiology. The blood culture results of patients with suspected bloodstream infections attending a tertiary care hospital using the BD PHOENIX FX &M50 system were collated & evaluated for rare pathogens between August 2023 and July 2024. **Results:** Out of 1759, 203 blood cultures were identified among 61.8% males (n=125) and 39.2%females (n=78). Of these 63% (n=128) were gram positive organisms & 37% (n=75) were gramnegative. Of these 10rare pathogens were isolated namely *Citrobacter farmeri, Comamonas terrigena, Elizabethkingia meningoseptica, Empedobacter brevis, Escherichia hermanni, Sphingomonaspaucimobilis, Ochrobactrumanthropi, Rhizobiumradiobacter* and *Stenotrophomonas maltophila* and *Pantoea agglomerans.* Most of these showed resistance to oneor the other class of antimicrobials. **Conclusion:** This study highlights that rare opportunistic organisms are detected by automated blood culture system which cannot be observed with traditional methods. So, we advocate that our microbiology labs up to district levels should be equipped with automated systems that will help early detection of sepsis due to rare pathogens, timely antimicrobial susceptibility, reducing hospital stay, healthcare costs and hence overcome the global challenge of antimicrobial resistance.

KEYWORDS : Automation, rare pathogens, blood stream infections

INTRODUCTION

Bloodstream infections pose a significant risk to patients, especially neonates, theimmunocompromised and those with indwelling devices. Manual blood culture methods while historically successful, often suffer from delays in detection, increased contamination rates and difficulties in identifying rare or fastidious organisms. While bloodstream infections (BSIs) are often attributed to well-known bacterial species, an underappreciated spectrum of rare opportunistic pathogens can also lead to severe complications, particularly in immunocompromised individuals and intensive care settings.

Emerging studies and case reports have documented bloodstream infections caused by organisms traditionally considered environmental or opportunistic, emphasizing the critical need for improved diagnostic surveillance. Automated blood culture and identification systems has demonstrated substantial benefits in terms of turnaround time, reduced human error and improved detection of both common and uncommon pathogens when compared to manual blood culture methods.

This paper makes the case for the adoption of automated blood culture and identification systems not just in tertiary care centres but in all laboratories up to the district level. Given the risingincidence of infections caused by emerging pathogens including *Elizabethkingia meningoseptica, Pantoea agglomerans , Sphingomonas paucimobilis* and *Stenotrophomonasmaltophilia,* decentralizing advanced diagnostic technology can help ensure prompt diagnosis, targeted therapy and better epidemiological surveillance.

MATERIALS AND METHODS

This is a retrospective hospital-based study, conducted over one-year period from August 2023to July 2024 in the Department of Microbiology at Sri Lal Bahadur Shastri Government Medical College (SLBSGMC), Mandi at Ner Chowk, Himachal Pradesh.

Blood culture results from patients with clinically suspected bloodstream infections admitted to various departments of our tertiary care hospital were systematically collated. Specimen processing, microbial detection and identification were performed using the BD PHOENIX FX and M50 automated blood culture systems. BD PHOENIX FX leverage continuous monitoring technique of microbial growth every 15 minutes by fluorescence detection of carbon dioxide in the media and advanced algorithms to rapidly flag culture positivity. When microorganisms are present in the test sample inoculated into the BD BACTEC vial, they metabolize nutrients in the culture medium, releasing CO_2 into the medium. A dye in the sensor at the bottom of the culture bottles will react with CO_2. This modulates the amount of light absorbed by a fluorescent material in the sensor. The instrument's photodetectors measure the fluorescence level, corresponding to the amount of CO_2 released by the organisms. Analysis of the rate and amount of CO_2 increase enables the BD BACTEC instrument to determine if the vial is positive, i.e., that the test sample contains viable organisms.[1]

The BD PhoenixM50 System uses a unique dual growth detection technology, combining an oxidation-reduction indicator and a turbidity measure for more accurate antimicrobial susceptibility results.In addition; it employs a delayed growth algorithm that defers reporting for slow-growing organisms until additional instrument readings are collected, which provides additional assurance that results are accurate.[2]

Automated BC bottles were incubated for up to 5 days according to manufacturer's instructions The evaluation focused on the detection of rare and opportunistic pathogens. Data on the incidence of these pathogens, along with their antimicrobial susceptibility profiles were analysed with an emphasis on clinical impact.

RESULTS

Out of 1759, 203 blood cultures were identified among 61.8% males (n=125) and 39.2% females (n=78). Of these 63% (n=128) were gram positive organisms & 37% (n=75) were gram negative. Coagulase negative staphylococci (n=98) were predominant among gram positive isolates, followed by *Staphylococcus aureus* (n=15),*Enterococcus sp.* (n=11) &*Streptococcus sp.* (n=4). *Escherichia coli* was predominant among gram negative isolates (n=15), followed by Acinetobacter sp. (n=13), Salmonella sp. (n=9), *Klebsiella pneumoniae* (n=8), Citrobacter sp. (n=5), *Empedobacter brevis* (n=4), *Enterobacter cloacae* (n=4), *Stenotrophomonas maltophila* (n=4), and one isolate each(n=1) of *Comamonasterrigena,*

Elizabethkingia meningoseptica, Escherichia hermanni, Sphingomonaspaucimobilis, Ochrobactrum anthropic, Rhizobium radiobacter and *Pantoea agglomerans*

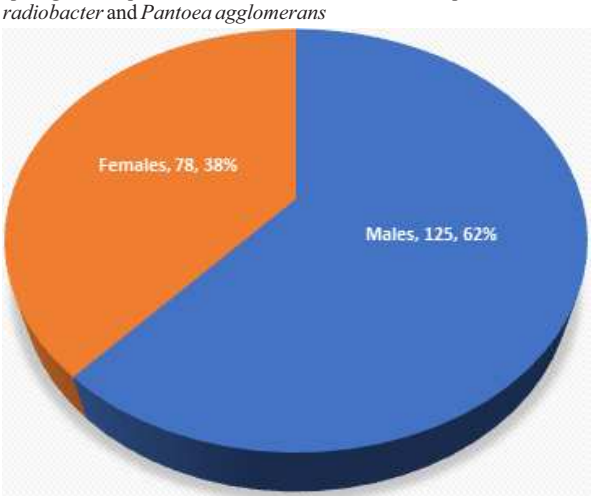

Figure 1: Gender-wise distribution of positive blood cultures.

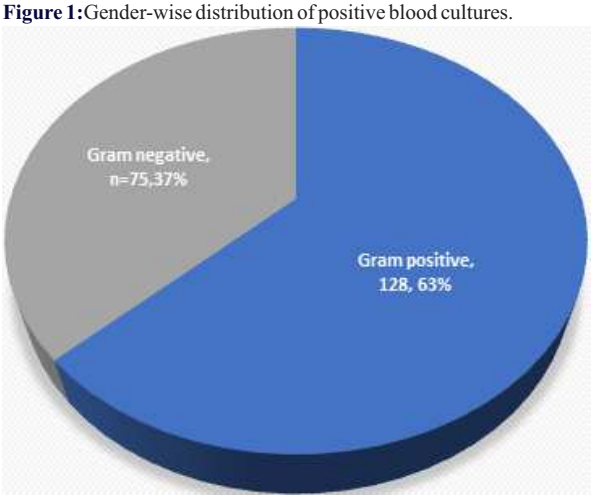

Figure2: Organism wise distribution of positive blood cultures.

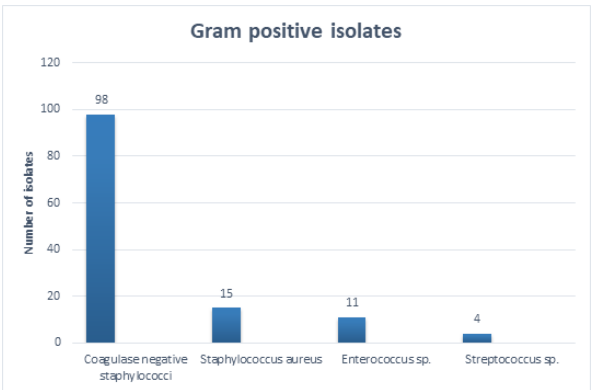

Figure 3: Gram positive isolates among positive blood cultures.

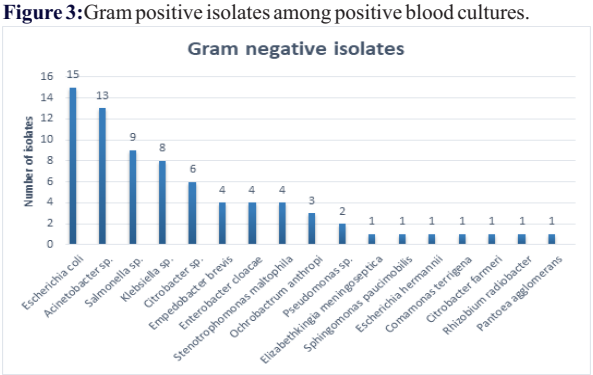

Figure 4: Gram negative isolates among positive blood cultures.

CASE 1: Blood culture from 88-year-old alcoholic, female patient who presented with discoloration of right great toe following trauma for 1 month along with fever with chills and altered sensorium revealed *Citrobacter farmeri.* Predisposing factors in this patient were uncontrolled diabetes mellitus due to poor compliance, acute kidney injury and anemia. The patient developed multiorgan failure, septic shock and died despite antibiotic treatment with in vitro active agents i.e., Piperacillin- tazobactam. Similar report by Raeseok Lee et al has highlighted opportunistic infections is predominant in the elderly patients with comorbidities.[3]

CASE 2: Blood culture from 60-year-old hypertensive, obese female patient with fatty liver who presented with high grade fever with chills revealed *Elizabethkingia meningoseptica* that was resistant to most routine antimicrobials. Urine culture from this patient grew *Klebsiella pnemoniae,* probably it increased the susceptibility of the patient to *E. meningoseptica.*However, patient responded to treatment with ciprofloxacin and gentamycin and was successfully discharged without complications. Graziella P. et al showed *E. meningoseptica* has increased, predominantly in patients with severe underlying diseases, surgical procedure and concomitant infections.[4] Manoj K. Sahu et al had showed similar findings,and the patient responded well to ciprofloxacin treatment to which Klebsiella was sensitive.[5]

CASE 3: Blood culture from a 48y old patient, with alcoholic liver disease with liver cirrhosis who presented with fever revealed *Ochrobactrum anthropi.* Isolate was resistant to beta lactams but susceptible to cotrimoxazole, fluoroquinolones, aminoglycosides and recovered with treatment. In the study by Hideharu H. et al similar antibiotic susceptibility results were seen.[6]

CASE 4: Blood culture from a 65y old patient, with moderately differentiated adenocarcinoma who presented with febrile illness revealed *Sphingomonas paucimobilis.*Similarly in a study by Ranjana Rohilla et al reportedmalignancy, immunosuppressive use & chronic diseases as risk factors for suchinfection.[7]

DISCUSSION

In our study some rare and opportunistic pathogens have been identified . The following table gives a summary of pathogenic potential , associated risk groups , opportunistic role and key features of these rare organisms.

The Need For Automation In Blood Culture Detection

The Advantages Of Automation Are:

1) Turnaround Time: Automated blood culture systems continuously monitor growth indicators (e.g., CO_2 production, oxygen consumption) and can detect microbial proliferation in as little as 6–8 hours for fast-growing organisms. This rapid detection is essential for starting timely antimicrobial therapy, especially in septic patients. By standardizing the inoculation process (using a 0.5 McFarland standard) and applying robust algorithms, these systems minimize operator-dependent variability.

2) Reduction in Contamination and Human Error: Manual blood culture methods often rely on periodic visual inspection, which increases the chance of overlooking early growth or mistaking contamination for true infection. Automated systems reduce these risks by providing continuous, objective monitoring and by interfacingdirectly with laboratory information systems (LIS), they also decrease manual data entry errors.

3) Enhanced Identification Accuracy: Integration with automated identification platforms—such as MALDI-TOF mass spectrometry and automated biochemical assays—allows for precise speciation of organisms. This is particularly critical for identifying rare and opportunistic pathogens that may otherwise be misclassified or dismissed as contaminants.

4) Enhanced Sensitivity and Specificity: The ability to continuously monitor and accurately interpret growth dynamics increases the likelihood of detecting low-level bacteraemia, including rare pathogens.

5) Standardization and Quality Control: Automated systems adhere to rigorous protocols that reduce variability and improve reproducibility across diverse laboratory settings.

6) Integration with Laboratory Information Systems (LIS): Such

integration enhances data management, facilitates trend analysis, and supports antimicrobial stewardship programs.

7) Cost-Effectiveness in the Long Term: Although initial investment may be higher, the long-term benefit of reduced hospital stays, improved patient outcomes, and decreased labour costs justify the widespread adoption—even in district-level laboratories.

Table 1: Rare Blood Stream Pathogens And Their Pathogenic Potentia

Organism	Pathogenic potential	Risk groups	Opportunistic role	Key features
Citrobacter farmeri	Moderate implicated in UTI , sepsis , neonatal meningitis	Diabetic , chronic liver disease, hospitalizedpatients	Nosocomial infections	Rising multidrug resistance, linked to urinary/abdominal sources.
Comamonas terrigena	Generally low, can lead to invasive infections[8]	Reported in patients with chronic conditions and immunosuppression	Occasional opportunist in compromised hosts	Occasional blood stream and GI infections.
Elizabethkingia meningoseptica	Multidrug resistant causing severe neonatal meningitis, sepsis and pneumoniae[9]	Primarily affects neonates patients and immunocompromised	Nosocomial in intensive care settings	High mortality ,multidrug resistance.
Empedobacter brevis	Low virulence ,can lead to neonatal sepsis[10]	Mainly infects neonates patients and immunocompromised	Environmental organism , invades opportunistically	Emerging pathogen
Escherichia hermanni	Low , co infecting agent	Seen in patients with immune impairment, indwelling devices, comorbidities[11]	Blood stream infections	Often part of polymicrobial infections.
Sphingomonas paucimobilis	Low intrinsic virulence, significant in nosocomial settings	Associated with malignancies, diabetes , indwelling catheter use , ICU patients	Common cause of HAI[12]	Biofilm formation, often linked to contaminated solutions and equipment
Ochrobactrum anthropi	Low but emerging opportunistic pathogen [13]	Associated with oncology patients, invasive devices	Device associated bacteremia	Biofilm production
Rhizobium radiobacter	Low, environmental organism, device related colonization.	Seen in hematologic patients or solid organ cancers.[14]	Causes CRBSI	Difficulties in identification, environmental contamination
Stenotrophomonas maltophila	High in vulnerable patients, multidrug resistant	ICU patients, malignancies	Opportunistic pathogen , nosocomial outbreaks	Notorious for intrinsic drug resisitance,biofilm producer[15]
Pantoea agglomerans	Low virulence , co-infecting agent	Associated with penetrating trauma, contaminated fluids, immunocompromised host.[16]	Catheter-related bacteremia, nosocomial infections.	Emerging opportunistic pathogen.

Pre-analytical & analytical errors are reduced by almost 50% using automated system when compared to traditional methods.[17]Different panels exist for different samples and age groups like paediatric panel, adult panel, yeast panel and even anaerobes can be detected.[18] Automated system is less labour intensive and up to 240 samples can be included at a time. It also gives M.I.C values for antimicrobials that helps a clinician to decide the dose and frequency of antimicrobials with narrow therapeutic range which is not found in traditional methods. The automated system's ability to recognize these pathogens rapidly can enhance patient outcomes, guide effective treatment strategies and reduce morbidity associated with undiagnosed infections.[19]Though the initial cost of the automated system is high but for long term it is cost effective.

The Way Forward

Expanding automated blood culture systems to district-level laboratories can be achieved by;

Centralized Procurement And Training: Governmental health agencies can partner with manufacturers to subsidize equipment costs and provide comprehensive training programs.

Scalable and Modular Systems: Compact systems (such as the BD Phoenix M50) allow for modular expansion based on test volume, making them suitable for smaller facilities.

Integration With Telemedicine And Remote Support: Data from district-level labs can be relayed to centralized expertise hubs, ensuring timely review and quality assurance.

Policy And Funding Support: National health policies should prioritize investment in laboratory infrastructure as part of broader strategies to combat antimicrobial resistance and improve rural health outcomes.

CONCLUSION

Automated blood culture systems represent a transformative innovation in clinical microbiology. Their ability to rapidly and accurately detect a broad spectrum of pathogens including rare and opportunistic organisms has profound implications for patient management and public health. The advantages of automation in terms of reduced turnaround time, improved sensitivity, decreased human error, and seamless integration with laboratory information systems make a compelling case for their adoption in all microbiology laboratories, including those at the district. level. By embracing automation, healthcare systems can ensure prompt diagnosis, optimized, patient care, and enhanced antimicrobial stewardship. So, we advocate that our microbiology labs up to district level should be equipped with automated culture and identification systems that will help in early detection of infections due to rare pathogens, obtain timely antimicrobial susceptibility, reducing hospital stay and healthcare costs. Future efforts should focus on scaling these technologies, providing targeted training, and integrating laboratory networks to support remote quality control. Such measures will build a more resilient diagnostic infrastructure, crucial for managing infections in the era of emerging resistance and complex nosocomial pathogens.

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