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COMPARATIVE STUDY OF AUTOMATED VS MANUAL BLOOD CULTURE SYSTEMS FOR DETECTION OF BLOODSTREAM INFECTIONS: A REVIEW

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ABSTRACT

Blood culture remains the diagnostic benchmark for identifying causative organisms in bloodstream infections and guiding antibiotic therapy, yet laboratories continue to weigh conventional manual systems against continuously monitored automated platforms such as BACTEC and BacT/ALERT 3D. This review synthesizes evidence from a comparative hospital-based study alongside the wider published literature on automated versus manual blood culture performance. Across the reviewed evidence, automated systems consistently demonstrated higher culture positivity rates (up to 60% versus 48% for manual methods in the primary study reviewed, and 37.2% versus 25% in a related cross-sectional dataset), shorter mean time to detection (12–24 hours versus 24–48 hours, and 21.4 versus 44.6 hours in a larger comparative series), and lower contamination rates than manual Brain Heart Infusion broth-based culture. Coagulase-negative Staphylococcus and Escherichia coli were the predominant isolates recovered by both methods, with automated systems recovering a modestly higher proportion of Gram-negative bacilli. Antimicrobial susceptibility testing showed Gram-positive isolates remaining highly sensitive to vancomycin and linezolid, while Gram-negative isolates showed the greatest sensitivity to amikacin, meropenem, and imipenem. These findings support automated blood culture systems as the preferred diagnostic approach in high-acuity and high-volume settings, while manual systems retain practical value in resource-constrained laboratories where cost and infrastructure limit automation.

KEYWORDS: Blood culture; Bacteremia; Septicemia; BACTEC; BacT/ALERT; Automated culture systems; Antimicrobial susceptibility; Bloodstream infection.

1. INTRODUCTION

Septicemia arises when circulating bacteria multiply in the bloodstream faster than they can be cleared by phagocytic defenses, and bloodstream infections remain a leading cause of morbidity and mortality worldwide, particularly in hospitalized and critically ill patients. Left untreated, such infections can disseminate to multiple organs and prove fatal, making rapid and accurate laboratory diagnosis essential to timely, targeted antimicrobial therapy. Blood culture remains the established reference standard for identifying causative organisms and their antibiotic susceptibility, but the method used to perform that culture, conventional manual systems or continuously monitored automated platforms, can materially affect how quickly and reliably a diagnosis is reached.

Manual blood culture systems, which rely on visual inspection of Brain Heart Infusion (BHI) broth bottles for turbidity, gas production, or visible colonies, were developed to serve settings with limited resources and remain attractive where equipment costs must be minimized. However, this approach is vulnerable to operator bias, delayed detection, and comparatively lower sensitivity. Automated systems such as BACTEC and BacT/ALERT 3D address these limitations through continuous, instrument-based monitoring that flags positive cultures in real time, typically reducing both time to detection and the length of hospital stay. This review synthesizes evidence, including a hospital-based comparative study of 100 clinically suspected septicemia cases, on how these two approaches compare across positivity rate, detection time, contamination, organism recovery, and antimicrobial susceptibility profiling.

2. Bacteriology of Bloodstream Infections

Bloodstream infections can be caused by a wide range of Gram-positive and Gram-negative organisms, many of which form part of normal human flora but become pathogenic under favorable conditions. Among Gram-positive organisms, Staphylococcus species (including coagulase-negative staphylococci and Staphylococcus aureus), Streptococcus species, and Enterococcus species are most frequently implicated, the latter tolerating bile salt concentrations up to 40% and inhabiting the lower gastrointestinal tract. Among Gram-negative organisms, Escherichia coli, Klebsiella species, Salmonella species (with reported bacteremia incidence of 5.2–13.7% for invasive strains), Pseudomonas aeruginosa,

Enterobacter species, and Proteus species account for the majority of isolates, with additional but less frequent recovery of Acinetobacter, Alcaligenes, Burkholderia, Brucella, Citrobacter, and Yersinia species. Recognizing this organism spectrum is essential context for interpreting the comparative recovery rates discussed later in this review, since automated and manual systems can differ in their sensitivity to particular organism groups.

3. Blood Culture Methodologies Compared

Manual blood culture relies on inoculating blood into BHI broth, a nutrient-dense medium enriched with calf brain and beef heart infusions, peptones, dextrose, and buffering and osmotic agents that support the growth of both fastidious and non-fastidious organisms. Bottles are incubated at 37°C and inspected daily for turbidity, gas bubbles, or visible colonies, a process that is inexpensive but dependent on the frequency and skill of visual inspection, introducing potential delay and observer variability.

Automated systems such as the BacT/ALERT 3D operate on a colorimetric detection principle: as microorganisms metabolize substrates in the broth, they produce carbon dioxide, which diffuses through a gas-permeable sensor at the base of the bottle and lowers its pH, triggering an irreversible color change from dark green/gray to yellow. The instrument continuously monitors reflectance from this sensor, plotting growth curves and alerting laboratory staff the moment a sample turns positive, without requiring manual inspection. This continuous, automated monitoring is the central mechanism behind the shorter detection times and improved sensitivity reported for automated systems throughout the literature.

4. Comparative Evidence on Diagnostic Performance

The hospital-based study at the center of this review examined 100 clinically suspected cases of septicemia processed in parallel by conventional BHI-based culture and automated BACTEC FX40/BacT-ALERT systems. Culture positivity was 48% with the conventional system versus 60% with the automated system, a gap consistent with a related cross-sectional analysis of 600 blood culture records reporting 25% positivity for manual methods versus 37.2% for automated methods. Mean time to detection was correspondingly faster with automation, ranging from 12–24 hours in the primary study to a mean of 21.4 hours in the cross-sectional series, compared with 24–48 hours and 44.6 hours respectively for manual culture. Contamination rates also favored the automated approach (1.7% versus 5.2% in the cross-sectional dataset), consistent with reduced manual handling and continuous rather than intermittent monitoring.

Parameter	Manual (Conventional) System	Automated System
Culture positivity rate	48% (25% in comparative series)	60% (37.2% in comparative series)
Mean time to detection	24–48 hours (44.6 h mean)	12–24 hours (21.4 h mean)
Contamination rate	5.2%	1.7%
Gram-positive cocci recovered	52.08%	45%
Gram-negative bacilli recovered	47.91%	55%
Predominant organism	Coagulase-negative Staphylococcus	Coagulase-negative Staphylococcus

Coagulase-negative Staphylococcus was the most frequently isolated organism by both methods, followed by Escherichia coli, indicating broad agreement in the dominant pathogen profile despite differences in overall yield. The automated system recovered a modestly higher proportion of Gram-negative bacilli relative to Gram-positive cocci, which the reviewed literature attributes partly to improved detection of fastidious and slower-growing organisms under continuous monitoring conditions. These findings are consistent with earlier comparative work reporting that automated systems detect pathogens in significantly shorter time frames than manual culturing and yield fastidious organisms more reliably, as well as pediatric studies noting greater automated detection of Staphylococcus aureus and Gram-negative bacilli.

5. Antimicrobial Susceptibility Patterns

Antimicrobial susceptibility testing of isolates recovered in the reviewed study, performed by the Kirby-Bauer disc diffusion method, showed clear patterns by organism group. Among Gram-positive isolates, coagulase-negative staphylococci showed 100% sensitivity to vancomycin, linezolid, and tetracycline; Staphylococcus aureus showed 88.9% sensitivity to linezolid and 77.8% to vancomycin and tetracycline; Enterococcus species showed 100% sensitivity to vancomycin, linezolid, and ampicillin; and Streptococcus species showed 100% sensitivity to vancomycin. Among Gram-negative isolates, Escherichia coli showed 100% sensitivity to amikacin, followed by meropenem and imipenem; Klebsiella species showed the highest sensitivity to amikacin, ciprofloxacin, gentamicin, and trimethoprim-sulfamethoxazole; and Pseudomonas, Proteus, and Acinetobacter species showed consistently

high sensitivity to amikacin across isolates. These patterns broadly agree with comparable studies reporting high vancomycin and linezolid sensitivity among Gram-positive organisms and amikacin- and carbapenem-centered sensitivity among Gram-negative organisms, reinforcing the clinical utility of rapid, automated pathogen identification for guiding empirical and targeted antimicrobial therapy.

6. CONCLUSION AND FUTURE DIRECTIONS

Taken together, the evidence reviewed confirms that automated blood culture systems offer meaningful diagnostic advantages over conventional manual methods, including higher positivity rates, shorter time to detection, and lower contamination, while recovering a broadly similar spectrum of causative organisms. These advantages make automated systems a trustworthy and increasingly preferred substitute for conventional blood culture, particularly in critical care and intensive care settings where rapid, accurate identification of bloodstream pathogens directly shapes antimicrobial therapy decisions. Manual systems, however, retain a legitimate role in resource-constrained laboratories where cost considerations outweigh the incremental diagnostic benefit of automation.

Future research would benefit from multicenter comparative studies across varied healthcare settings and patient populations, closer evaluation of cost-effectiveness alongside diagnostic performance to guide resource allocation decisions, and continued monitoring of evolving antimicrobial susceptibility patterns to ensure that empirical therapy protocols remain aligned with local resistance trends. Integration of automated blood culture data with molecular identification methods and antimicrobial stewardship programs represents a further avenue for improving the speed and precision of bloodstream infection management.

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