Blood Culture: A Critical Tool for the Health Care Professional

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Blood culture

- BSIs are associated with high rates of morbidity and mortality
- blood culture remains the gold standard for its diagnosis

Halperin AV,del Castillo Polo JA,Cortes-Cuevas JL,Cardenas Isasi MJ,Ampuero Morisaki M,Birch R, Sánchez Díaz AM, Cantón R,, 2022. Impact of Automated Blood Culture Systems on the Management of Bloodstream Infections: Results from a Crossover Diagnostic Clinical Trial. Microbiol Spectr 10:e01436-22.

Rapid microbiological investigations

- identification of the causative agent & AST are therefore very important:

- to adjust the anti-infectious therapy

- to reduce the spectrum of the anti-infectious therapy

- to limit the toxicity

Opota O, Croxatto A, Prod'hom G, Greub G. Blood culture-based diagnosis of bacteraemia: state of the art. Clin Microbiol Infect. 2015 Apr;21(4):313-22.

Microbe identification

- from a subculture
- from the positive blood culture using nucleic-acid-based methods: hybridization, microarray
- after a bacterial enrichment and purification step to obtain a ‘bacterial pellet’: MALDI-TOF MS

Opota O, Croxatto A, Prod'hom G, Greub G. Blood culture-based diagnosis of bacteraemia: state of the art. Clin Microbiol Infect. 2015 Apr;21(4):313-22.

Blood culture quality

- pre-analytical phase: patient identification criteria, container usage, sample integrity/identification, written orders, collection time & blood culture volume
- analytical phase: quality control performance & sample storage
- post-analytical phase: report accuracy, critical values reporting, TAT & culture contamination rate

Sciacovelli L, Aita A, Padoan A, Pelloso M, Antonelli G, Piva E, Chiozza ML, Plebani M. Performance criteria and quality indicators for the post-analytical phase. Clin Chem Lab Med. 2016 Jul 1;54(7):1169-76.

Blood culture quality metrics

- quality of BC collection is a key determinant of clinical utility:

- taking at least two BC sets from different sites
- inoculation of 8–10 mL blood per bottle
- restricting contamination to <3% of all cultures

Williams J, Hills A, Ray M, Greenslade J. Changing culture: An intervention to improve blood culture quality in the emergency department. Emerg Med Australas. 2024 Feb;36(1):133-139.

Blood culture quality assurance indicators – collection, processing & reporting

- The RCPA recommends laboratories develop and monitor QAIs to include but are not restricted to:

- blood volume collected
- BC contamination rate
- BC positivity rate
- timely gram stain report communication to clinicians

https://www.rcpa.edu.au/getattachment/fd33b7ad-da8e-4e56-a1f8-962184be9832/Blood-Culture-Quality-Assurance-(BCQA)-Indicators.aspx

Improving the blood culture pathway

- NHS England and NHS Improvement make the following four recommendations for improving the blood culture pathway;

- recommendation 1: build upon existing national guidance and best practice

- recommendation 2: implement local monitoring to identify areas for improvement ~ collection-to-load time into the incubator & volume of blood

- recommendation 3: AMS & AMR to be a core part of clinical leadership and trust governance

- recommendation 4: improve regulation and accreditation

https://www.england.nhs.uk/wp-content/uploads/2022/06/B0686-improving-the-blood-culture-pathway-executive-summary-v1-1.pdf.pdf

Changing culture: An intervention to improve blood culture quality in the ED

- single culture sets reduced from 56.2% to 22.8% & 18.8% sustainability
- underfilled bottle rates were also significantly reduced
- skin contaminants were grown from 3.7% of BC sets in the pre-intervention period, improving to 1.5% in the post-intervention period ($P < 0.001$) and 2.1% in the sustainability period ($P = 0.03$)
- total volume of blood cultured was significantly associated with diagnosis of bacteraemia

Williams J, Hills A, Ray M, Greenslade J. Changing culture: An intervention to improve blood culture quality in the emergency department. Emerg Med Australas. 2024 Feb;36(1):133-139.

Association between blood culture turnaround time and clinical prognosis in ED patients with community acquired bloodstream infection: A retrospective study based on electronic medical records

- overall 30-day all-cause mortality rate was 13%
- no statistically significant differences were observed in clinical prognosis between the TAT groups
- in patients with delayed antibiotic treatment (>3 h), a shorter TAT was significantly associated with a fatal outcome

Hsu PH, Chang R, Yin CH, Chen YS, Chen JS. Association between blood culture turnaround time and clinical prognosis in emergency department patients with community acquired bloodstream infection: A retrospective study based on electronic medical records. Heliyon. 2024 Mar 15;10(6):e27957.

What's Next?

Comparison of time to appropriate antibiotic between using microarray assay and MS technique for identification of positive BCs

- significantly faster bacterial identification and detection of antibiotic resistance (39.34 hours vs. 5 hours, $P = 0.0001$) as well as time to adjust specific antibiotic therapy (75 hours vs. 27.65 hours, $P = 0.0001$)
- earlier appropriate antibiotic therapy (31 hours vs. 0 hours, $P = 0.005$) & decrease unnecessary of antibiotic adjustment (51.4% vs. 37.3%)
- all-cause mortality within 2 weeks was not significantly reduced (11.4% vs. 14.7%), no differences cost of antibiotic therapy and length of hospital stay (13 days vs. 17 days)

Sakulkonkij P, Salee P, Katip W. 2126. Comparison of Time to Appropriate Antibiotic Between Using Microarray Assay and Mass Spectrometry Technique for Identification of Positive Blood Cultures. Open Forum Infect Dis. 2019 Oct 23;6(Suppl 2):S720.

Short turnaround time of 7-9 hours from sample collection until informed decision for sepsis treatment using nanopore sequencing

- pathogen identification was possible at as low as 10^2–10^4 CFU/mL, achieved after just 2 h of incubation & within 40 min of nanopore sequencing
- all the antimicrobial resistance genes were identified at 10^3–10^7 CFU/mL, achieved after incubation for 5 h & only 10 min to 3 h of sequencing
- total TAT from sample collection to the information required for an informed decision on the right antibiotic treatment was between 7 and 9 h

Ali, J., Johansen, W. & Ahmad, R. Short turnaround time of seven to nine hours from sample collection until informed decision for sepsis treatment using nanopore sequencing. *Sci Rep* 14, 6534 (2024).

Rapid nanopore sequencing and predictive susceptibility testing of positive blood cultures from intensive care patients with sepsis

- species-level agreement between conventional methods and AST predicted from sequencing was 94.2%, increasing to 100% in monomicrobial infections
- CA was 89.3%, with ME and VME rates of 10.5% & 12.1%
- time to reporting from sequencing could be achieved within 8–16 h from BC positivity
- Oxford Nanopore Technologies-based approaches may be faster but significant improvements in accuracy are required before it can be considered for clinical use

Harris PNA, Bauer MJ, Lüftinger L, Beisken S, Forde BM, Balch R, Cotta M, Schlapbach L, Raman S, Shekar K, Kruger P, Lipman J, Bialasiewicz S, Coin L, Roberts JA, Paterson DL, Irwin AD. Rapid nanopore sequencing and predictive susceptibility testing of positive blood cultures from intensive care patients with sepsis. Microbiol Spectr. 2024 Feb 6;12(2):e0306523.

Thank You for Your Attention!