Burden of blood culture contamination

False positive blood cultures lead to unnecessary treatment and prolonged hospital stays. **Étáin O'Keefe RGN** and **Stuart Murray** discuss the importance of preventing the clinical and economic burden of blood culture contamination.

Blood culture is considered to be the 'gold standard' method of investigation for the detection of microorganisms in the blood that lead to the diagnosis of serious infections. However, blood cultures continue to be a source of frustration to clinicians and microbiologists and a burden to healthcare systems due to erroneous results caused by contaminated samples.

The universally 'acceptable' blood culture contamination (BCC) rate is currently quoted as 3%.[1] Although with many papers discussing different methods of reducing BCC rates and with new technology coming to the market there is now an argument that for such an important diagnostic tool, this rate should be significantly lower.[1] Studies from both North America and Europe illustrate widely varying contamination rates between institutions, from as little as 0.6% to over 10%.[2]

In UK & Irish hospitals BCC is reported on average as 5% false positive rate. With 3.5M blood cultures performed annually results in approximately 175,000 false positive blood cultures a year. This creates an enormous burden within an already stretched clinical environment and heightens the need for diagnostic testing to be accurate and reliable.

What is a blood culture contamination?

Blood culture contamination (BCC) usually occurs due to accidental cross contamination of a microorganism during the collection phase of the sample.[1] Tests can become contaminated from several sources such as the patient's skin, the equipment used to take the sample, the hands of the person taking the blood sample, or the environment.

Emergency departments are regularly identified as the main source of high contamination rates within hospitals.[1, 3, 4] This may be due to high staff turnover rates, high numbers of blood cultures taken in emergency departments, fast paced nature of the environment or taking cultures from a venous access device that may have already been used and thus contaminated.[1] BCC can also be caused by defective skin antisepsis or incompletely decolonised skin fragments becoming dislodged by venepuncture.[5]

Skin antisepsis using a sterile 2% chlorhexidine and 70% isopropyl alcohol applicator is evidenced as one of the best preventative measures for reducing contamination rates. However, more than 20% of the skin flora (microorganisms) may be beyond the reach of disinfection because microorganisms are located in pilosebaceous units (hair follicles, glands etc.)[5] thus meaning that, even with adequate education and aseptic procedure, there is a percentage of bacteria than cannot be sterilised and may become a source of contamination.

It is widely reported today that nearly half of all positive blood cultures isolated are the result of a contamination[6] highlighting that almost equal amounts of effort and resources are put into false positive samples and patient's treatment as truly positive blood cultures.

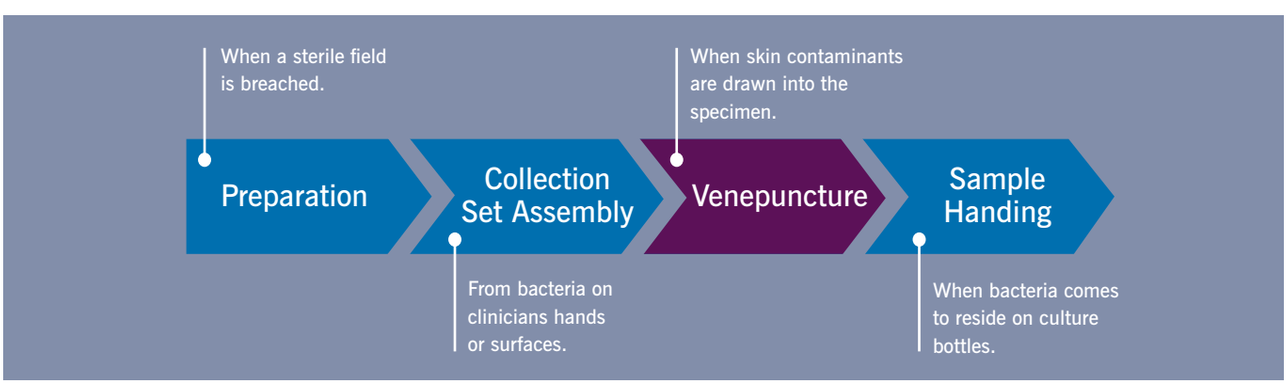
Contamination creates clinical uncertainty and often results in detrimental downstream effects.[7] False positive results due to a contamination can prolong a hospital stay and trigger the administration of unnecessary antibiotics, placing patients at risk of complications from unneeded therapy, such as allergic reaction, and increased susceptibility to opportunistic infections like *Clostridium difficile* colitis.

These unintended consequences add significant additional healthcare costs, inconvenience for patients, occupy resources (hospital inpatient beds), delay treatment for others and increase length of stay in hospital.

Patient impact

Blood culture is a critical tool for healthcare staff, as it allows for both the identification and the subsequent targeting of specific microorganisms.[3]

However, contaminated samples producing incorrect results compromise the integrity of blood cultures as a diagnostic tool and place patients at risk of misinformed prognoses and incorrect targeted therapies. In cases where blood culture is used ▶



to diagnose bacteraemia, which has a significant morbidity and a mortality rate of up to 37%, any delay in treatment due to identifying more than one causative organism could be fatal for patients.[8]

The largest proportion of false-positive blood cultures (50–85%) result from contamination with coagulase-negative staphylococci which is primarily found on the skin.[3] However, if found in the bloodstream and not from contamination they are a significant cause of bacteraemia.[9] Because of this, clinicians cannot ignore these results and a positive blood culture result of coagulase-negative staphylococci often requires immediate treatment of broad-spectrum antibiotics.

Unnecessary antibiotics are prescribed in 40-50% of cases of BCC[10] and needless use of antibiotics for patients' conflicts with the efforts to combat and improve global antimicrobial stewardship.

Studies confirm an association between contaminated blood culture samples and increased length of hospital stay (LOS) for patients.[3,5,6] As can be shown in Table 1, increased LOS is estimated to range from 2.5-8.0 additional days in hospital.[5,6,11,12] This is important as unnecessary hospitalisation can lead to hospital-acquired infections (HAIs), including *Clostridium Difficile,*[5] pneumonia and MRSA. Studies also show that 8% of hospitalised patients are exposed to HAIs, of which 20% can be multi-drug resistant[13] and as patients' LOS is increased, the risk of exposure to HAIs grows exponentially.

Study	Increased LOS (in days)	Cost per contamination	Estimated total savings (with intervention)	BCC estimated total cost to a hospital
Bates *et al* (1991)[11]	8 - 12.5	$8,731 - $13,116	not reported	Not reported
Zwang *et al* (2006)[6]	Not reported	Not reported	Not reported	$1.4 mil - $1.8 mil
Gander *et al* (2009)[25]	4-5	$8,720 (additional charges)	Phlebotomist Team $4.1 mil	Not reported
Alahamadi *et al* (2011)[12]	5.4	£5,001	Not reported	£1,270,381
Geisler *et al*[5]	2.35	$6,436	Phlebotomist Team $1.3 mil	Not reported

Table 1: Increased LOS in days, cost per contamination, total savings with intervention, and estimated total cost to hospitals.

Antimicrobial stewardship

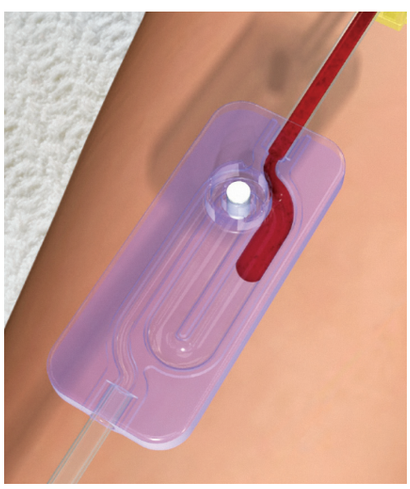
Antimicrobial resistance is a significant global threat to public health.[13] Analysis by Lord Jim O'Neill predicts that by 2050, 10 million deaths worldwide will be attributable to antibiotic resistant infections.[14] A microbe's primary function is to survive, and, when faced with drugs that can kill them such as antibiotics, they mutate and form resistance, resulting in bacterial infections that cannot be treated.[15]

Resistant microorganisms and multi-drug resistant infections are exacerbated by poor practices within hospitals and in the community, such as over prescribing of broad-spectrum antibiotics and poor infection control practices, thus requiring the need for antimicrobial stewardship efforts.

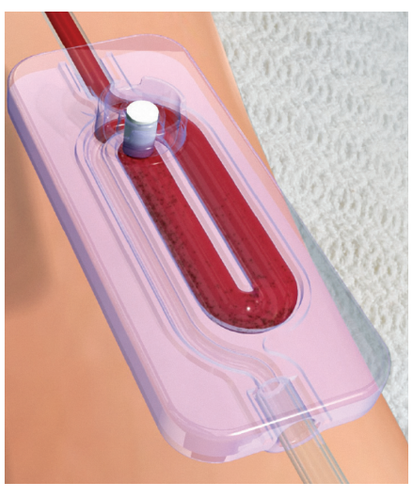
Antimicrobial stewardship is a set of coordinated measures to help tackle further creation and introduction of drug resistant microorganisms.[16] Key elements of antimicrobial stewardship include; correct antibiotic prescribing, correct dosing, only prescribing antibiotics for suspected bacterial infections and not prescribing for viral infections.[16]

This global initiative is endorsed by the World Health Organization as well as the Health Service Executive (Ire) and the National Health Service NHS (UK). While antimicrobial stewardship is recognised by many clinicians as a key factor to the future of healthcare, false-positive blood culture results misguide clinicians and microbiologists. BCC is a leading cause of unnecessary prescription of broad-spectrum antibiotics[4] which subsequently undermines the antimicrobial stewardship effort.

As previously discussed, bacteraemia pose too high a risk to patients' lives[8] to go untreated if tests show positive results. However, knowing how frequently these results are falsely positive highlights the strain BCC has on the global antimicrobial stewardship initiative.



Serves as a flash chamber to provide visual confirmation of proper needle placement in the vein.



Contaminants residing in the initial ~0.15ml volume of blood are captured in the u-shaped Kurin Lock

Blood flows directly from the vein into the culture bottle through a separate channel.

Hospital management

Overcrowding in hospitals is a common and extremely difficult problem to rectify in many well-developed countries. With average global life expectancy increasing, greater numbers of patients present with one or more comorbidity. This results in more complicated health complaints and social care issues thus increasing the LOS in hospitals and episodes of 'bed blocking'.[17] The consequence of 'bed-blocking' is extended waiting times for elective patients, patients being left on trolleys in emergency departments and delays in treatments for other inpatients.

These complications often result in a chain of administrative problems for bed management and hospital administrative teams such as procedure rescheduling, re-staffing and repeatedly moving patients to different areas in a hospital.[17] Reducing blood culture contamination rates is one potential way to regain hospital bed days that are occupied by false positives.[6,12] One study calculated that 254 false positive blood cultures had cost Antrim Area Hospital (NI) 1372 extra bed days.[12] Regaining these days is a simple efficiency measure that will lighten the burden of 'bed blocking' for hospitals.

Financial Implication

Blood culture contamination has a large financial impact on hospitals and patients. Contamination creates a burden on resources within hospitals and the significance of these financial implications may not be immediately clear as they will be distributed across many parts of the organisation. Increased costs are due to LOS, greater antibiotic use, increased diagnostic testing and subsequent laboratory time.[18]

Indeed, compared with true negative results, false positive results were independently associated with a 20% increase in laboratory charges and a 39% increase in intravenous antibiotic charges.[11] High rates of contaminants are a clear fiscal burden to the laboratory as they necessitate the retesting of samples, or obtaining new samples, which is time consuming and a drain on staff resources.

Increased LOS is often discussed as one of the main financial burdens for hospitals. As with actual cost per contamination, increased LOS due to a blood culture contamination can differ in studies. However, it is reliably quoted as being between 2-8 days.[5,6,11,12] This increase in LOS has important financial implications given that beds come at a daily cost to hospitals. The NHS quoted a non-elective 'bed day' as costing £1,603[20] and similarly, Dublin based Irish hospitals quote the 'full economic cost of an average bed day' as €1,223-1,597.[20] Increased LOS, due to blood culture contamination, could therefore result in significant unnecessary costs to hospitals (see Table 1).

The macro financial burden of false positive blood cultures to the UK & Irish healthcare systems is potentially enormous. Taking 175,000 false positives (UK), at an average contamination rate of 5%, creates financial wastage of approximately £875M annually. New technology offers an opportunity to significantly reduce this financial burden.

How can we reduce blood culture contamination?

Blood culture contamination is a complex and challenging problem,[3] but there are now multiple interventions that can be utilised to aid in the significant reduction of BCC. Clear procedural protocols with education and regular staff training,[21] accompanied with the use of procedure kits including evidence based technology[3] have all helped to get BCC rates to the current levels of between 4% and 5%, which is still notably above the universally 'acceptable' BCC of 3%.[1]

New technology in the form of a specimen diversion device, Kurin, has recently been made available in the UK & Ireland. The blood culture collection system has been proven to significantly reduce BCC. When collecting a sample for blood culture, the device automatically diverts the initial 0.15ml of blood into an alternative locking chamber.

This directs the potential source of contamination away from the blood collection bottles, thus allowing for more accurate blood culture results. The product is a passive intervention, which does not require a change in clinicians' chosen practice of venepuncture.[22] Kurin has been shown to reduce contamination rates by up to 90%, even in hospitals with BCC rates lower than the accepted 3%.[23,24] Data from hospitals who use this product estimate savings ranging from $260,000 -$1.3M, depending on initial rate of BCC and number of blood cultures taken.[22]

Summary

Contaminated blood cultures create a significant clinical and financial burden on the healthcare system, and it is imperative that hospital management and clinicians are made aware of and recognise these ongoing issues. Contamination of blood cultures and false positives create significant financial burdens to every department involved in the processing of blood cultures. Patients experience negative outcomes in the form of unnecessary antibiotic treatment, further testing and extended hospital stays, which in a COVID-19 environment comes with an elevated risk.

Relatively low upfront costs can yield incredibly high returns for hospitals by implementing mixed strategies including blood culture procedure kits utilising new evidence-based technology, such as Kurin, and implementation of protocol education.

For a blood culture test to be revered as the 'gold standard' it needs to be upheld as having the lowest possible error rate and negative effects on patients and hospitals. With some simple interventions we can now have in sight a possible zero blood culture contamination standard and thus improve patient outcomes. CSJ

References available on request

About the authors

Étáin O'Keefe RGN, is an ICU nurse and clinical specialist in IV Access at Iskus Health. Having spent 6 years nursing in surgical wards and ICUs in the UK & Jersey Channel Islands her focus has shifted to clinical education around evidence-based technologies in the area of vascular access. She has a special interest in blood cultures and improving contamination rates.

Stuart Murray is the commercial director at Iskus Health. Having spent over 20 years commercialising medical devices, he has a passion for clinically evidenced based technology which improves patient outcomes. Delivering significant and sustainable reductions in blood culture contamination through simple innovative solutions has been a key mission at Iskus Health for over 15 years.