Effectiveness of introducing blood culture collection packs to reduce contamination rates

A. I. BAMBER, J. G. CUNNIFFE, D. NAYAR, R. GANGULY and E. FALCONER
Wirral University Teaching Hospitals NHS Foundation Trust. Clatterbridge Hospital, Bebington CH63 4JY, UK

Accepted: 16 December 2008

ABSTRACT

Contaminated blood cultures result in a significant waste of healthcare resources and can lead to inappropriate antibiotic therapy. Practitioners have taken measures to reduce contamination rates. These include thorough skin disinfection, effective hand decontamination, introduction of a standardised approach to collection, and the introduction of blood culture collection packs (BCCP). This study aims to assess the impact of introducing BCCP and staff training on the rate of contamination. The study demonstrated that contamination rates are greatest in high patient throughput units where practitioners are under most pressure. The introduction of blood culture packs and staff training has reduced contamination rate significantly from 43% to 25% of the total number of positives, equating to an overall reduction of 42%. Thus, there is a demonstrable benefit in the purchase of commercially produced blood culture packs and the investment in staff training.

KEY WORDS: Bacterial contamination.
Blood culture.
Collection pack.

Introduction

Detection of bacteraemia is of vital importance in the determination of the causative organism in a wide range of infectious conditions including endocarditis, pneumonia, osteomyelitis and pyrexia of unknown origin (PUO).[1] Early positive results provide valuable information to guide targeted antimicrobial therapy, thereby helping to reduce mortality and the selection of multiresistant bacteria.[2] Normally the bloodstream is sterile; however, bacteria may enter the bloodstream from a focus of infection or from a site such as the skin or a mucous membrane colonised with normal flora.

Blood is cultured using semi-automated continuous monitoring systems in the majority of laboratories. In May last year, Wirral University Teaching Hospital elected to go out to tender for a new system to replace its existing BacTec 9240 (BD Diagnostic Systems, NJ, USA). The tender specification was advertised in OJEU and a weighted scoring system was used to assess the merits of each potential replacement against a detailed specification. The BacT/ALERT 3D (bioMérieux, France) was deemed to offer the closest match.

Inevitably, the introduction of a new blood culture system requires close liaison with the users during implementation, and we decided to use this opportunity to introduce blood culture collection packs (BCCP) with a view to reducing the blood culture contamination rate.

Contaminated blood cultures can lead to inappropriate antibiotic therapy. This may result in a significant waste of healthcare resources and also exposes the patient to the side effects of antimicrobial therapy.[2] Antimicrobial resistance due to unnecessary exposure has been reported widely, but a patient's physical and psychological reactions to additional testing and prolonged hospitalisation are also important considerations.[3]

Contamination of blood cultures is a common problem, accounting for up to 50% of all positive cultures.[1,4] Interpretation can be difficult, as common skin commensals can be pathogens in patients who have intravascular catheters or synthetic cardiac valves, and in the immunocompromised.

Correspondence to: Andrew Bamber
Email: andrew.bamber@whnt.nhs.uk

Conversely, pathogens may colonise the skin and can contaminate the blood culture if poor technique is employed. *Staphylococcus aureus* (including methicillin-resistant *S. aureus* [MRSA]) can be isolated from patients who have no apparent focus of infection; however, even if the organism is deemed to be a contaminant, it may still contribute to an organisation's healthcare-associated infection surveillance data, and can influence adversely the attainment of targets.

Assessing the clinical significance of a blood culture isolate requires a review of both the clinical picture (e.g., focus of infection/previous history/risk factors) and multidisciplinary laboratory results. Inflammatory markers (e.g., C-reactive protein) and the patient's white blood cell count may indicate infection, but there is not necessarily a cause–effect relationship with the isolate, especially if antibiotic therapy has been initiated prior to blood culture collection.

Pyrexia is normally present in serious infection, but it is not an invariable finding. In addition, microbiologists commonly use time to positive culture and whether the isolate is present in one or both bottles (or multiple sets) to aid determination of likely significance.

Contamination may occur at any stage between the taking of blood and processing in the laboratory.[5] Blood cultures may be contaminated with skin commensals or environmental organisms. Pseudobacteraemia occurs when isolates originate from outside the patient's bloodstream and may result in unnecessary or inappropriate therapy.[2,6] A

range of possible sources of contamination exists, including: the skin of the patient; the fingers or even mouth of the practitioner; the environment; from laboratory contamination of vented systems, and contamination from other blood collection tubes.[7,8]

However, in an extensive study undertaken by the College of American Pathologists, the type of blood culture method used, the specimen volume or the use of a double-needle collection procedure did not affect contamination rates significantly.[5] Accordingly, there are various ways of reducing contamination.

Interventions have focused on the training of staff to collect blood cultures correctly,[9] and specially trained or dedicated phlebotomists have also been used.[10,11] Various antiseptic agents used for skin disinfection prior to blood collection have been compared,[12] with a solution of 2% chlorhexidine in 70% alcohol proving to be the most effective agent.[13,14]

A combined approach to reducing contamination has the potential to be the most effective. Successful measures include: correct technique when sampling blood; thorough disinfection of the venepuncture site; effective hand decontamination; introduction of a standardised approach to collection; use of easy, safe sampling systems that incorporate butterfly devices, and the use of lines rather than a syringe and needle; laboratory use of non-vented systems; and the introduction of BCCP.

Blood culture collection packs have been used with apparent success in other trusts, but there is little published evidence to confirm that they are effective in reducing contamination; however, Eskira *et al*.[9] have reported that a reduction in blood culture contamination rates can be achieved through the use of a proper sampling technique and by staff education.

The new blood culture system and BCCP were introduced at Wirral University Teaching Hospital in December 2007. Infection control staff worked in conjunction with the hospital's clinical skills laboratory to train all practitioners over a one-week period to correspond with the time of the launch.

As part of a systematic change control process, we elected to undertake several key audits including pre- and post-intervention contamination audits and an examination audit to assess compliance with the protocol, and the effectiveness of the standard operating procedure (SOP) when processing a positive blood culture. The last highlighted deficiencies in the SOP that have since been corrected, but the primary focus of this report is the contamination audit results.

The aims of this pre/post-intervention audit are to i) determine which wards/units had the highest blood culture contamination rates, ii) assess the impact of the new blood culture system and the introduction of BCCP, augmented by practitioner training, on blood culture contamination rates, and iii) determine the value of purchasing commercially prepared BCCP

Materials and methods

Blood culture collection packs contained two blood culture bottles (one aerobic BacT/ALERT FA bottle containing charcoal, and one standard BacT/ALERT SN anaerobic bottle

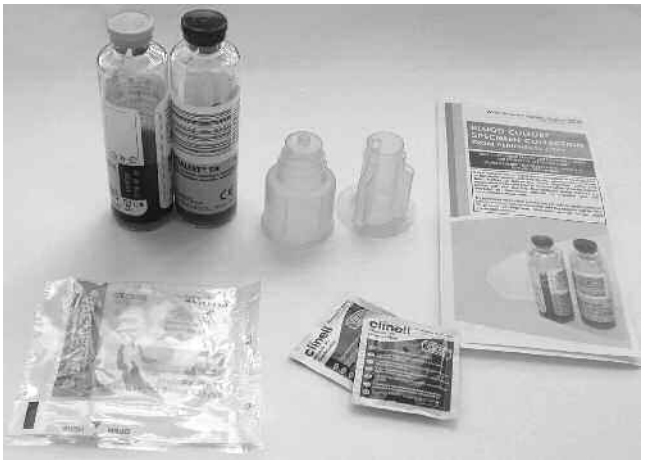

Fig. 1. Contents of a blood culture collection pack.

[bioMérieux, France]), one safety blood collection set with Leur adapter (Greiner Bio-One, Austria), two BacT/ALERT blood collection adapter caps (bioMérieux) two Clinell 2% chlorhexidine wipes (Gama Healthcare, UK) and one information leaflet (Greiner Bio-One) (Fig. 1).

Audit design aimed to assess the contamination rate in approximately 100 positive blood cultures prior to the introduction of the new BCCP and staff training, and a similar number directly after introduction.

Collection of audit data was achieved using adapted standard trust audit forms in order to standardise collection. We recorded the location of all blood cultures collected during the audit. The pre-intervention audit covered the contamination rate two months prior to system change in 100 consecutive positive blood cultures (1–31 October 2007). The post-intervention covered the contamination rate in the two months immediately after introduction of BCCP and staff training, which yielded 167 consecutive positive blood cultures (4 January to 24 March 2008).

Definitions used in the audit were 'obvious pathogen' (organism deemed by laboratory medical staff to be clearly responsible for bacteraemia at the time of clinical review), 'possible contaminant' (organism that may be responsible for bacteraemia in the appropriate clinical setting but where the significance of the isolate in this case was deemed to be uncertain), and 'probable contaminant' (organism determined to be a contaminant at the time of review by laboratory medical staff).

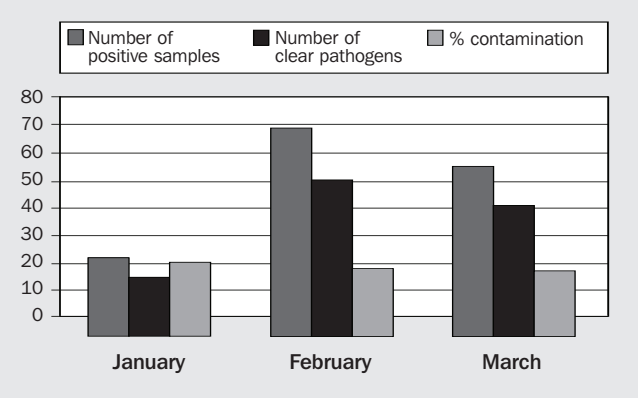

Fig. 2. Number of positive blood cultures *vs*. contamination rates post-intervention.

Table 1. Partial data showing the patient location of contaminated blood cultures in units with the highest contamination rates.

Unit	Pre-intervention		Post-intervention		Reduction (%)
	No.	Positive (%)	No.	Positive (%)	
Accident and Emergency	14	61	20	47	22
Clinical Decisions Unit	10	71	1	10	86
Medical Assessment Unit	2	33	2	11	67
Surgical Ward (A17)	6	85	1	25	71

Table 2. Organisms isolated during pre-Intervention audit.

Organisms	Clear pathogen	Possible contaminant	Probable contaminant
Coagulase-negative staphylococci	14	10	28
Corynebacterium spp.	0	1	4
Staphylococcus aureus	11	0	0
Enterobacteriaceae	18	0	0
Pseudomonas spp.	5	0	0
Listeria spp.	2	0	0
Streptococci	5	0	0
Enterococci	2	0	0
Anaerobes	1	0	0

Results

Table 1 includes partial data showing the patient location of contaminated blood cultures in units with the highest contamination rates. Table 2 lists the organisms isolated during the pre-intervention audit. Table 3 lists the organisms isolated during the post-intervention audit. Table 4 provides a summary of contamination rates. Figure 2 plots the number of positive blood cultures against the post-intervention contamination rates.

Discussion

It is not surprising that emergency admission and high throughput wards (Table 1), which are under pressure from staff shortages, high staff turnover and national clinical targets, showed the highest contamination rates in the preliminary study. However, most wards demonstrated a reduction in contamination rates post-intervention, especially those that originally produced the highest contamination rates (Table 1).

Coagulase-negative staphylococci (CoNS) were the most frequent contaminants in both pre- and post-intervention studies (Tables 2 and 3). They will continue to challenge us, especially in the high-dependency setting where they are also possible pathogens. Many of the patients on a busy surgical ward from whom CoNS were isolated had intravascular lines and were receiving total parenteral nutrition. In these cases, the significance of the isolate was uncertain.

Table 3. Organisms isolated during post-Intervention audit.

Organisms	Clear pathogen	Possible contaminant	Probable contaminant
Coagulase-negative staphyloccci	23	11	28
Corynebacterium spp.	0	0	4
Staphylococcus aureus	17	0	0
Enterobacteriaceae	41	0	0
Pseudomonas spp.	1	0	0
Streptobacillus moniliformis	1	0	0
Streptococci	20	0	0
Enterococci	8	0	0
Anaerobes	1	0	0
Mycobacteria	5	0	0
Yeasts	9	0	0

Although the number of positive blood cultures increased between January and March, the contamination rate declined (Table 4). There was an overall 42% reduction in the total contamination rate after the BCCP was introduced, which supports the findings of Eskira *et al.*[9] and clearly demonstrates that the intervention was effective (Fig. 2).

We would support Juamaa and Chattopadhyay's belief that contaminated cultures lead to inappropriate antibiotic therapy. If a clinician is uncertain about whether or not an organism is significant, they will apply caution and treat the patient.

A 14-day course of antibiotic is recommended for the treatment of *Staphylococcus aureus* bacteraemia. Many CoNS infections require treatment with glycopeptides (as isolates are often resistant to flucloxacillin) if an essential intravenous line cannot be removed. A two-week course of vancomycin (750 mg b.d.) costs £236 (excluding assay costs, 'giving sets' and nursing time). A 14-day course of teicoplanin (400 mg o. d.) costs £490. Extended stay in hospital due to treatment of pseudosepsis costs approximately £170 per day (£1200 per day in our ITU).[15]

Based on usage of 9402 sets per annum, we agreed a price with Merseyside Courier Service (MCS), Bowring Park,

Table 4. Summary of contamination rates.

	Pre-intervention		Post-intervention		Reduction (%)
	No.	(%)	No.	(%)	
Samples	100	100	167	100	
Possible contaminant	11	11	9	5	55
Probable contaminant	32	32	32	19	41
All contaminants	43	43	41	25	42

Liverpool, of £0.63 per set. This included initial and ongoing expenses to ensure packs were made under clean conditions (our own infection control team inspected the premises). Components are ordered via MCS, invoiced and delivered to the hospital supplies department and then collected by MCS, which also manages stock control for the wards/departments. Greiner Bio-One did not levy a charge for the production of information leaflets. This represents an outlay of £5934.60

Laboratory consumables cost approximately £2.30 per positive blood culture. Staff time for processing positive samples and reading subsequent cultures (30 min per sample, mid-point Band 6) costs £8.30 (including on-costs). Based on the laboratory workload for 2007, reducing contamination by 42% eliminates 617 positive cultures, thus saving £6540.20 (more than the cost of producing the blood culture packs). If we include additional consultant input, this cost would rise significantly, although actual savings are unrealistic. However, many consultants would welcome a reduction in workload.

These figures, together with the anticipated reduction in the number of notifiable false-MRSA bacteraemias, lead us to conclude that there is measurable benefit associated with the introduction of BCCP. This evidence convinced the trust to fund the production of BCCP and deliver regular training as a cost-effective measure to improve patient care.

It is unlikely that the introduction of BCCP alone will have reduced contamination rates so dramatically; staff education and training will also have had a significant part to play. However, compliance is likely to decline over time, thus reducing effectiveness if practitioner training is not reinforced. Therefore, it is essential to provide feedback to relevant departments, staff and service users in order to highlight the positive outcome of this audit.

The introduction of trained phlebotomy teams is planned for the near future, and it would be prudent to repeat this audit to see whether or not contamination rates can be reduced still further.

Conclusions

- Contamination rates are highest in high-throughput units where practitioners are under most pressure.
- Introduction of blood culture packs, together with training, has reduced our contamination rate (from 43% to 25%) by 42%.
- There is measurable benefit associated with the purchase of commercially produced blood culture packs and investment in staff training – savings are made over the cost of consumables and biomedical scientist time; however, the potential is far greater when consultant time, pharmacy costs and extended bed occupancy are included.
- A robust mechanism for production of BCCP is imperative, and can be accommodated by a local service provider. □

Thanks are due to Gaynor Roberts, senior biomedical scientist in microbiology at WUTH, for assistance with data collection; Alison Quinn, Carmel Edwards and the WUTH Infection Control Team for undertaking the implementation of the new BCCP; Kevin Jones, bioMérieux UK, for assistance with the smooth implementation of the new system; and Greiner Bio-One for providing the information leaflets. There have been no commercial pressures or incentives to produce this report.

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