Unique blood culture for diagnosis of bloodstream infections in emergency departments: a prospective multicentre study

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Abstract

Detection of microorganisms by blood cultures (BCs) is essential in managing patients with bacteraemia. Rather than the number of punctures, the volume of blood drawn is considered paramount in efficient and reliable detection of microorganisms. We performed a 1-year prospective multicentre study in adult emergency departments of three French university hospitals comparing two methods for BCs: a unique blood culture (UBC) collecting a large volume of blood (40 mL) and the standard method of multiple blood cultures (MBC). The performances of both methods for bacterial contamination and efficient microbial detection were compared, each patient serving as his own control. Amongst the 2314 patients included, three hundred were positive for pathogens (n = 245) or contaminants (n = 55). Out of the 245 patients, 11 were positive for pathogens by UBC but negative by MBC and seven negative by UBC but positive by MBC (p 0.480). In the subgroup of 137 patients with only two BCs, UBC was superior to MBC (p 0.044). Seven and 17 patients had contaminated BCs by UBC and MBC only, respectively (p 0.062). Considering the sums of pathogens missed and contaminants, UBC significantly outperformed MBC (p 0.045). Considering the complete picture of cost savings, efficient detection of microorganisms and decrease in contaminations, UBC offers an interesting alternative to MBC.

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Introduction

Detection of bacteraemia and fungaemia by blood culture (BC) is essential in managing patients with bloodstream infection (BSI) [1]. Many studies have shown that increasing the number of BCs increases the likelihood of isolation of microorganisms [2–5]. It is a standard recommendation that two to four BCs should be obtained over a 24-h period for the optimal detection of BSIs in adults [6,7].

The volume of blood drawn is now considered paramount in efficient detection of microorganisms. This notion is based on many studies of patients with bacteraemia [4,8–12]. Li *et al.* demonstrated that increasing cultured volume from 20 to 40 mL increased yield by 19% [9]. Collecting only one BC should be discouraged because it results in an inadequate volume of cultured blood and therefore lacks sufficient sensitivity for detecting BSI [6]. Also, it is more challenging to distinguish between contamination and true bacteraemia.

Contaminated BCs may lead to longer hospital stays, unnecessary antibiotic therapy, redundant laboratory testing,

unnecessary removal of the catheter in patients with a central venous line and induce wasteful spending [13]. The multiple venipunctures required to obtain several sets of BCs are all opportunities for contamination.

To reconcile the need to collect large volumes of blood for efficient diagnosis of BSI and the need to minimize the contaminations by limiting the number of venipunctures, we have designed a prospective multicentre study comparing a unique BC (UBC) collecting a large volume of blood (40 mL) with the standard method of multiple BC (MBC) in patients presenting to the emergency department with a suspicion of BSI. We hypothesized that a UBC would decrease the number of contaminations and detect a similar number of pathogens, as compared with MBC.

Materials and Methods

Study design

This prospective, comparative, multicentre study involved emergency departments of three French university hospitals in Caen (1495 beds), Lille (2965 beds) and Rouen (2445 beds). The study included BCs obtained from consecutive patients aged ≥18 years from January to December 2012. However, the study had to be interrupted for holidays because of staff shortages.

BCs were collected from patients admitted with one of the following signs: fever (≥38.5°C), hypothermia (≤36°C), chills or shock.

For the first BC, 40 mL of blood was obtained aseptically by a single phlebotomy and equally distributed into two BacT/Alert FA aerobic bottles and two BacT/Alert FN anaerobic bottles (bioMérieux, La-Balme-les-Grottes, France). The four bottles were labelled prior to the venipuncture from one to four, in the following order, aerobic-anaerobic-aerobic-anaerobic, and filled in according to the numbering. Within the next 24 h, one to three other 20-mL BCs consisting of a single pair of aerobic and anaerobic bottles had to be performed, spaced by a minimum of 30 min. Bottles were incubated for 5 days or until positivity was reported by the BacT/Alert 3D instrument (bioMérieux).

The study was designed to compare the UBC and the MBC methods, with each patient being his own control: for MBC analysis, the first bottle pair was mimicked by taking into account the culture results of the first two bottles of the UBC set (see Supplementary Fig. S1). Hereafter, the mimicked MBC was called MBC.

The exclusion criteria were the following: patients <18 years, patients for whom direct venipuncture was impossible, patients who had an invasive procedure during the first 24 h of hospitalization, patients for whom the first four-bottle set was not labelled or labelled in incorrect order, and patients for whom subsequent two-bottle sets were not obtained.

Clinicians were free to prescribe two or more BCs. Skin disinfection was performed using similar protocols in the three centres based on alcoholic povidone-iodine as a disinfectant before each venipuncture.

This study was submitted to and approved by the local ethics committee. Given the observational nature of this study, in accordance with French legislation, written information was delivered to the patients or, if not possible, to their relatives.

Definitions of contaminants and pathogens

Microorganisms isolated from BCs were studied by standard microbiological techniques. A positive BC was defined as growing with one or several microorganisms, regardless of the number of bottles.

Contaminants. Cultures of coagulase-negative staphylococci (CoNS) (aside from *Staphylococcus lugdunensis*), coryneform bacteria, non-pneumococcal viridans streptococci, *Propionibacterium*, *Bacillus* and *Micrococcus* species, whatever the number of positive BCs, were considered as potential contaminations. The number of positive bottles and clinical data (including fever, chills, hypotension, neutropenia, antibiotic administration, catheter management and bacteriology of infected sites) were reviewed to evaluate the clinical significance of a potentially contaminated BC. Infectious diseases physicians conducted medical reviews (see Supplementary Appendix S1 for more details). In particular, the presence of CoNS in more than one set of BCs was considered as a contamination when the species identifications or antibiotic susceptibility profiles were different and when the physician review indicated no clinical evidence of infection.

Pathogens. Other organisms, such as *E. coli* or *Staphylococcus aureus*, not requiring several positive sets of BCs to be considered as pathogens, were classified as pathogens in the study [2]. When bacteraemia were polymicrobial, each microorganism was investigated independently.

Statistical analysis

Assuming that 2% of BCs (i.e. 20% of positive BCs) would be contaminated, including a level of contaminants of 8% or more in MBC only and 2.7% in UBC only (three times less because UBC gives rise to three less opportunities for contamination compared with MBC), we planned to include 200 positive BCs to be able to demonstrate a significant reduction of contaminants in UBCs as compared with MBCs. The culture results of UBCs were compared with those of MBCs. Analyses were carried out separately and then combined for pathogens and