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Controlled Clinical Comparison of Plastic versus Glass Bottles of BacT/ALERT PF Medium for Culturing Blood from Children

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The plastic pediatric BacT/ALERT (bioMérieux, Durham, N.C.) PF (PPF) is a new nonvented aerobic culture medium in a clear plastic bottle designed to prevent breakage. We compared the performance of the new PPF bottle to that of the present glass BacT/ALERT PF bottle for the recovery of microorganisms as well as for the time to detection of growth in samples of blood obtained for culture from children. We found that the PPF and PF bottles were comparable for recovery of microorganisms and that the safety advantage of plastic bottles can be achieved without compromising performance.

Culturing of blood for microorganisms is essential for diagnosing children with suspected bloodstream infection. Glass bottles have been used routinely in blood culture systems; however, breakage of glass bottles, although a rare event, may compromise the integrity of a blood specimen and may expose healthcare workers to infectious blood-borne pathogens. To reduce these risks, bioMérieux, Inc. (formerly Organon Teknika, Durham, N.C.), has developed an aerobic culture medium in a clear plastic bottle for the BacT/ALERT automated continuously monitoring blood culture instrument. Similar to the glass nonvented BacT/ALERT PF (PF) bottle, the new plastic nonvented PF (PPF) bottle contains a casein–soy-based medium, activated charcoal, and an atmosphere of carbon dioxide, oxygen, and nitrogen. This design results in an increased absolute volume of oxygen, allowing the bottles to be incubated without transient venting. Nonvented media have performed comparably, if not superior, to vented media (2) and have the added benefit of reducing the risk for sharp injuries that can occur during venting. We compared the new plastic PPF bottle to the present glass PF bottle for both the recovery and the time to detection of the growth of microorganisms in samples of blood obtained for culture in children with suspected bloodstream infection.

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From October 2000 to March 2002, blood was collected from children who were presented to Duke University Medical Center with suspected bloodstream infection. Institutional review board approval was obtained prior to the study, and all blood cultures were performed as part of standard patient care. The volume of blood collected for culture was at the discretion of the clinician and depended upon the child's age and weight; between 0.1 to 5 ml of blood was obtained over 95% of the time. According to instructions with each blood culture kit, aliquots of blood obtained by venipuncture were to be distributed equally between the glass PF and plastic PPF aerobic bottles. Each bottle was weighed before inoculation and upon receipt in the laboratory. If the total volume of blood was greater than 5 ml, blood volumes of bottle pairs had to be within 20% of each other to be included in the analysis. If the total volume of blood was less than 5 ml, blood volumes of bottle pairs had to be within 50% of each other to be included in the analysis. Bottles from each culture set were placed in the BacT/ALERT instrument and were incubated for 5 days or until they signaled positive. Based on Gram stain results, aliquots of blood-broth mixture were subcultured to appropriate media and were incubated per laboratory protocol. Subsequent identification of microorganisms was performed by standard laboratory methods (3). Gram-stain-negative bottles were returned to the instrument for the remainder of the 5-day incubation period or until they were reflagged by the instrument. False positives were defined as bottles that were Gram stain and subculture negative after the instrument signaled positive. Negative bottles from companion positive sets were subcultured at the end of the 5-day protocol, and if microorganisms grew on subculture, these bottles were defined as false negatives. These subcultures were performed specifically for the study.

An infectious disease physician reviewed each positive culture and coded it as clinically significant, a contaminant, or an isolate of unknown clinical importance based on previously published criteria (5). Episodes of bloodstream infection were defined by growth of a clinically significant blood culture isolate without recovery of a different microorganism during the succeeding 7-day period. If a different clinically significant microorganism was recovered within 72 h, the two isolates were considered a polymicrobial episode (not included in the analysis). If a different microorganism was recovered after 72 h, the second isolate was considered a new episode. Data from each phase of the study (before and after modification of the sensor) were analyzed separately. Statistical analysis of results was performed with the modified chi-squared test described by McNemar (1).

Findings for phases I and II of the study were similar, and there was no difference in false positives with the revised sensor. Hence, the following results represent combined data. A total of 6,729 blood culture sets were received that contained

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TABLE 1. Comparative yield of clinically significant isolates in PF (glass) versus PPF (plastic) aerobic blood culture bottles[a]

Microorganism(s)	No. of isolates recovered from:		
	Both bottles	PF only	PPF only
Staphylococcus aureus	9	2	0
Coagulase-negative staphylococci	57	5	13
Streptococcus spp.[b]	7	3	1
Enterococcus spp.	30	3	4
Bacillus spp.[c]	1	0	2
Enterobacteriaceae[d]	31	5	4
Other gram-negative bacteria[e]	22	6	3
Yeasts[f]	38	4	11
All microorganisms	195	28	38

[a] The *P* value was not significant in any case.
[b] Includes viridans group streptococci (*n* = 4), *Streptococcus pneumoniae* (*n* = 4), *Streptococcus pyogenes* (*n* = 1); and *Streptococcus bovis* (*n* = 2).
[c] Includes *Bacillus cereus* (*n* = 2) and *Bacillus* sp. (*n* = 1).
[d] Includes *Klebsiella pneumoniae* (*n* = 16), *Escherichia coli* (*n* = 10), *Serratia marcescens* (*n* = 6), *Enterobacter cloacae* (*n* = 4), *Enterobacter aerogenes* (*n* = 2), *Klebsiella oxytoca* (*n* = 1), and *Citrobacter koserii* (*n* = 1).
[e] Includes *Rhizobium radiobacter* (*n* = 6), *Burkholderia cepacia* (*n* = 6), *Stenotrophomonas maltophilia* (*n* = 5), *Acinetobacter* sp. (*n* = 5), *Pseudomonas* sp. (*n* = 4), *Pseudomonas aeruginosa* (*n* = 3), and *Aeromonas hydrophila* (*n* = 2).
[f] Includes *Candida krusei* (*n* = 13), *Candida lipolytica* (*n* = 11), *Candida tropicalis* (*n* = 10), *Candida albicans* (*n* = 9), *Candida parapsilosis* (*n* = 9), and *Candida lusitaniae* (*n* = 1).

TABLE 2. Episodes of monomicrobial bacteremia or fungemia by PF (glass) and PPF (plastic) aerobic culture bottles[a]

Cause of episode	No. of episodes detected by:		
	Both bottles	PF only	PPF only
Staphylococcus aureus	5	0	0
Coagulase-negative staphylococci	27	1	2
Streptococcus spp.[b]	6	2	1
Enterococcus spp.	7	0	0
Bacillus cereus	0	0	1
Enterobacteriaceae[c]	16	3	1
Other gram-negative bacteria[d]	15	2	3
Yeasts[e]	12	1	1
All microorganisms	88	9	9

[a] The *P* value was not significant in any case.
[b] Includes viridans group streptococci (*n* = 2), *Streptococcus pneumoniae* (*n* = 4), *Streptococcus pyogenes* (*n* = 1), and *Streptococcus bovis* (*n* = 2).
[c] Includes *Escherichia coli* (*n* = 8), *Klebsiella pneumoniae* (*n* = 4), *Serratia marcescens* (*n* = 3), *Enterobacter cloacae* (*n* = 3), *Klebsiella oxytoca* (*n* = 1), and *Citrobacter koseri* (*n* = 1).
[d] Includes *Burkholderia cepacia* (*n* = 4), *Stenotrophomonas maltophilia* (*n* = 4), *Pseudomonas aeruginosa* (*n* = 4), *Pseudomonas* sp. (*n* = 2), *Acinetobacter* sp. (*n* = 4), *Rhizobium radiobacter* (*n* = 1), and *Aeromonas hydrophila* (*n* = 1).
[e] Includes *Candida krusei* (*n* = 1), *Candida tropicalis* (*n* = 3), *Candida albicans* (*n* = 5), *Candida parapsilosis* (*n* = 4), and *Candida lusitaniae* (*n* = 1).

both study bottles, including 4,194 (62%) with an adequate volume of blood in both PF and PPF bottles. From one or both study bottles, 261 clinically significant microorganisms were isolated, representing 97 patients. Overall, clinically significant isolates were detected with equal frequency in both study bottles. However, coagulase-negative staphylococci and yeasts were detected more frequently from PPF (*P* values were not significant) (Table 1). Only 4 of 13 pneumococcal isolates were recovered from bottles that met criteria for comparable volume. For the other nine isolates where the volume of blood was substantially greater in one or the other bottle, the pattern of isolation was similar. Importantly, of the 13 pneumococcal isolates, only 5 were isolated from both bottles.

Of the 104 episodes, 88 were monomicrobial. When analyzed by episode, there were no significant differences in the recovery of microorganisms between PF and PPF for monomicrobial episodes (Table 2). For 261 clinically significant microorganisms, 190 (75%) isolates were recovered from both PF and PPF bottles within 72 h, and the mean time to detection was similar for both bottles (21.2 h for PF versus 20.8 h for PPF) (Table 3). Of the 4,194 paired blood culture bottles, there were 8 false-positive bottles in PF (0.2%) and 21 in PPF (0.5%). Terminal subcultures from negative glass PF companion bottles to sets with a positive PPF bottle yielded one *Staphylococcus aureus* isolate (unknown clinical significance). The PPF bottles had three false negatives, i.e., one *Acinetobacter baumanii* (clinically significant) and two coagulase-negative staphylococci (unknown clinical significance). Contaminants were isolated with equal frequency from PF bottles and PPF bottles (PF and PPF, 24; PF, 25; PPF, 19; *P* values were not significant).

In our study, the overall performance of the aerobic nonvented plastic bottle was similar to that of the glass bottle for the recovery of clinically significant microorganisms as well as for the time to detection of growth for pediatric patients with suspected bloodstream infection. Our finding that pneumococci were isolated from one bottle only more than half the time emphasizes the importance of volume in pediatric practice. In contrast, Snyder et al., in a comparison of plastic and vented glass BacT/ALERT blood culture bottles for adult patients, reported that 13 of 14 *Streptococcus pneumoniae* isolates were recovered from both bottles (4). In accord with our findings, Snyder and colleagues isolated more coagulase-negative

TABLE 3. Comparative time to positivity of clinically significant bacteria and fungi when both aerobic PF (glass) and PPF (plastic) culture bottles were positive within 72 h

Microorganism(s)	No. of isolates	Mean time to positivity (h)	
		PF	PPF
Staphylococcus aureus	9	23.2	25.6
Coagulase-negative staphylococci	57	29.4	27.8
Streptococcus spp.[a]	7	17.1	19.0
Enterococcus spp.	29	11.1	11.2
Bacillus cereus	1	8.7	8.0
Enterobacteriaceae[b]	30	9.5	10.8
Other gram-negative bacteria[c]	22	17.3	17.5
Yeasts[d]	35	29.2	27.9
All microorganisms	190	21.2	20.8

[a] Includes viridans group streptococci (*n* = 4), *Streptococcus pneumoniae* (*n* = 1), *Streptococcus pyogenes* (*n* = 1), and *Streptococcus bovis* (*n* = 1).
[b] Includes *Klebsiella pneumoniae* (*n* = 11), *Escherichia coli* (*n* = 7), *Serratia marcescens* (*n* = 4), *Enterobacter cloacae* (*n* = 4), *Enterobacter aerogenes* (*n* = 2), *Klebsiella oxytoca* (*n* = 1), and *Citrobacter koseri* (*n* = 1).
[c] Includes *Rhizobium radiobacter* (*n* = 6), *Burkholderia cepacia* (*n* = 3), *Pseudomonas* sp. (*n* = 3), *Acinetobacter baumanii* (*n* = 3), *Pseudomonas aeruginosa* (*n* = 2), *Stenotrophomonas maltophilia* (*n* = 2), *Aeromonas hydrophila* (*n* = 2), and *Acinetobacter* sp. (*n* = 1).
[d] Includes *Candida parapsilosis* (*n* = 9), *Candida krusei* (*n* = 7), *Candida lipolytica* (*n* = 7), *Candida tropicalis* (*n* = 6), *Candida albicans* (*n* = 5), and *Candida lusitaniae* (*n* = 1).

staphylococci from the plastic bottle. The reason for this finding, as well as our observation that yeasts were detected more frequently in the plastic bottle, is unclear (4). Although there was no difference in performance of the two bottles by monomicrobial episode, there were insufficient numbers in this study to analyze polymicrobial episodes.

In summary, the plastic bottle is lighter and virtually break resistant, thereby ensuring the integrity of the blood culture specimen and reducing the risk of exposure of healthcare personnel to infectious substances. Based on performance comparable to that of glass and the potential for important safety benefits, we recommend the use of plastic PF bottles in the BacT/ALERT blood culture system.

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