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Comparison of the BacT/Alert FAN Aerobic and the Difco ESP 80A Aerobic Bottles for Pediatric Blood Cultures

P. L. WELBY-SELLENRIEK, D. S. KELLER, R. J. FERRETT, AND G. A. STORCH*

Edward Mallinckrodt Department of Pediatrics, Washington University School of Medicine, St. Louis, Missouri

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We compared the BacT/Alert system using the aerobic FAN bottle with the ESP system using the 80A aerobic bottle for the detection of pediatric bloodstream pathogens at a children's hospital. From 6,636 blood culture sets complying with the inclusion criteria, 308 pathogens were detected, including 177 that were detected by both systems, 69 that were detected by BacT/Alert FAN only, and 62 that were detected by ESP 80A only ($P = 0.6$; not significant). BacT/Alert FAN detected more isolates of *Staphylococcus aureus* (47 versus 34; $P = 0.02$), while ESP 80A detected more episodes of streptococcal and enterococcal infection. BacT/Alert FAN detected more pathogens from patients receiving antibiotic therapy (107 versus 93; $P = 0.04$). Of 248 separate episodes of bacteremia or fungemia, 146 were detected by both systems, 56 were detected by ESP 80A only, and 46 were detected by BacT/Alert FAN only ($P = 0.37$; not significant). The median times to detection were 13.6 h for ESP 80A and 15.7 h for BacT/Alert FAN ($P < 0.001$). Both systems were considered easy to operate and were free from significant mechanical difficulties. False-positive or false-negative signals were rare or nonexistent with both systems. We conclude that both systems rapidly detect a broad range of pediatric bloodstream pathogens. BacT/Alert FAN provides better detection of *Staphylococcus aureus*, especially from patients receiving antibiotics. ESP 80A provides better detection of streptococci and enterococci.

Three continuously monitored noninvasive blood culture systems, the BacT/Alert (Organon Teknika, Durham, N.C.) (13), the ESP (Difco Laboratories, Detroit, Mich.) (5), and the BACTEC 9240 (Becton Dickinson Instruments, Sparks, Md.) (6) systems, are in widespread use. The BacT/Alert and Bactec 9240 systems monitor for organism growth by checking for elaboration of CO_2 with a colorimetric (BacT/Alert) or a fluorescent (BACTEC 9240) sensor. The ESP system monitors pressure changes within the blood culture bottle resulting from the production or consumption of gas by microbial growth.

A number of studies carried out with specimens from patients in adult or general hospitals have shown that these systems rapidly detect a wide range of bloodstream pathogens (1, 3, 5–11, 13, 14, 17–19, 21). Fewer studies have been published to date on the use of these systems with specimens from pediatric patients. A medium developed for the BacT/Alert system (Pedi-BacT) for use with specimens from pediatric patients showed that organism recovery was better and more rapid than that with a conventional system (4). In our laboratory, we showed that the ESP 80A aerobic bottle achieved comparable organism recovery and more rapid detection compared to those achieved with the BBL-Roche Septi-Chek biphasic system (17).

Recently, a new medium called FAN was developed for use in the BacT/Alert system to enhance the recovery of fastidious organisms and to improve the detection of bacteremia in patients receiving antibiotics. The FAN medium has a brain heart infusion base and contains Ecosorb, an additive which includes absorbent charcoal and Fuller's earth. Both aerobic and anaerobic FAN bottles have been shown to improve organism recovery compared to that achieved with standard aerobic and anaerobic BacT/Alert bottles (14, 19). These studies were carried out with specimens from general hospital populations. In the present study, we compared the BacT/Alert aerobic FAN bottle with the Difco ESP 80A aerobic bottle for the detection of pediatric bloodstream infections. The ESP 80A bottle is optimized for the recovery of aerobic pathogens and contains 80 ml of modified tryptic soy-based medium. It relies on the large broth/blood ratio to dilute the effects of antibiotics and other inhibitory factors in the patient's blood.

* Corresponding author. Mailing address: Department of Pediatrics, Washington University at St. Louis Children's Hospital, One Children's Place, St. Louis, MO 63110. Phone: (314) 454-6079 (work) and (314) 727-9548 (home). Fax: (314) 367-3765. E-mail: Storch@a1.kids.wustl.edu.

MATERIALS AND METHODS

Blood collection. The study was performed at St. Louis Children's Hospital between September 1994 and August 1995. Bottles were preweighed in the laboratory and were assembled into two- or three-bottle sets that included a FAN bottle and an ESP 80A bottle with or without an ESP 80N anaerobic bottle, plus an instruction sheet. Physicians, nursing teams, and phlebotomists were instructed on proper collection techniques. The recommended blood volume was 1 ml per year of age, which was divided equally among the bottles. If the blood volume obtained was greater than or equal to 1.5 ml, it was divided equally among three bottles; otherwise, it was divided between the FAN bottle and the ESP 80A bottle. No minimum volume of blood was required for inclusion in the study. During the first half of the study, blood was inoculated first into the ESP 80A bottle; during the second half of the study the order was reversed. During the entire study period, the Isolator system (Wampole Laboratories, Cranbury, N.J.) was also in use in the hospital for quantitative cultures, which were most often performed for patients in the pediatric intensive care unit who had central venous catheters and arterial catheters in place. Blood specimens collected in Isolator tubes were not included in the present study.

Blood culture processing. Upon receipt in the laboratory, the volume of blood inoculated was calculated by weighing the bottles and comparing the weight to the preinoculation weight. Sets were included in the study if there was no more than a twofold difference in blood volume between the FAN bottle and the ESP 80A bottle. The FAN and ESP 80A bottles were vented after the tops were cleaned with 70% isopropyl alcohol and were placed simultaneously on the respective instruments. Blood culture sets were transported promptly to the laboratory via dumbwaiters, and laboratory personnel were available on all shifts to process the bottles. Thus, there was no preincubation or delayed entry.

Each instrument was operated according to the manufacturer's standard instructions. The standard period of incubation was 5 days. Any bottle with a positive signal was immediately removed from the instrument and an aliquot was taken for Gram staining and subculture. If the Gram staining result was positive, the bottle was considered positive and the time to detection was taken as the time when the instrument signaled positive, as recorded by the instrument. If the Gram staining result was negative, the bottle was placed back on the instrument. These bottles were considered positive if the instrument signaled positive again and the result of a repeat Gram staining was positive or if the first subculture was

positive. The time to detection was taken as the time when the repeat Gram staining or the subculture result was positive. These criteria were the same as those used to notify physicians of positive blood cultures. Positive signals that were not confirmed by Gram staining or culture were considered false-positive signals. Bottles from the two systems were processed independently of one another, except that the contents of a negative companion bottle of any bottle that was positive for a pathogen or contaminant was subcultured at the end of 5 days of incubation. Regardless of the results of the subculture, these bottles were considered negative for the purposes of analysis. However, if the subculture was positive, the bottle was counted as providing a false-negative signal.

Clinical assessment. All isolates were designated as probable pathogens or possible contaminants on the basis of the following criteria. Probable pathogens were microorganisms such as *Staphylococcus aureus*, group A or B streptococcus, *Streptococcus pneumoniae*, *Pseudomonas aeruginosa*, members of the family *Enterobacteriaceae*, and *Candida* species that are usually considered bloodstream pathogens and that were recovered as single isolates or as one of multiple isolates along with other probable pathogens. If one of these organisms was isolated in combination with other organisms that were possible contaminants, the patient's chart was reviewed by an infectious disease specialist who then designated the organism as a probable pathogen or a possible contaminant. Any isolate that is usually considered a constituent of normal skin or upper respiratory flora, such as a coagulase-negative staphylococcus, was listed as a pathogen only if it was isolated from more than one blood culture set and if the isolates had identical antibiotic susceptibility profiles. For isolates for which susceptibility testing was not performed, the patient's chart was reviewed by an infectious disease specialist and the significance of the episode was judged as described above.

Data analysis. All patient data, such as medical record number, accession number, bottle lot number, volume of blood in each bottle, and time of entry and removal of the bottle from each instrument, were entered into the clinical data management program on the BacT/Alert system. For positive blood cultures, additional information including time to detection, classification of the organism, mode of detection (i.e., by Gram staining or subculture), and whether or not the patient was receiving antibiotics when the culture was obtained was also recorded. Two or more isolates of the same organism from a single patient were considered to represent a single episode unless more than 5 days had elapsed between consecutive cultures.

Statistical analysis. The statistical significance of differences in the recovery of isolates from the two systems was evaluated by the chi-square test for paired data (McNemar's test). The significance of times to detection by each system was evaluated by the Wilcoxon test.

RESULTS

During the 11-month study period, a total of 7,813 blood culture sets were collected for inclusion in the study. Among these sets, 5,169 included an anaerobic bottle. The analysis of the results was limited to the 6,636 (84.9%) sets that met the criteria for inclusion in the study. In these sets, the mean volumes of blood inoculated were 1.16 ml in the BacT/Alert FAN bottle and 1.10 ml in the ESP 80A bottle. This small excess in volume inoculated in the BacT/Alert FAN bottle occurred in both the first and second halves of the study, even though the order of filling of the bottles was reversed.

From the sets complying with the inclusion criteria, 308 pathogens were isolated, including 177 that were detected by both systems, 69 that were detected only by BacT/Alert FAN, and 62 that were detected only by ESP 80A (Table 1). This difference in detection was not statistically significant. The most notable difference in the detection of individual organisms was greater detection of *Staphylococcus aureus* by BacT/Alert FAN (47 versus 34 isolates; $P = 0.02$). There was a trend toward greater detection of streptococci and enterococci by ESP 80A (93 versus 77 isolates), but the differences for individual species were not statistically significant.

The effect of antibiotic therapy is indicated in Table 2. For the purposes of this analysis, patients were considered to be receiving antibiotics only if the pathogen isolated was susceptible to the antibiotic that the patient was receiving. The increased detection of *Staphylococcus aureus* by BacT/Alert FAN was largely accounted for by increased recovery from patients receiving antibiotics.

The detection of episodes of bacteremia is indicated in Table 3. Of a total of 248 episodes, 146 were detected by both systems, 56 were detected only by ESP 80A, and 46 were detected only by BacT/Alert FAN. This difference was not statistically significant ($P = 0.37$). The same trends for individual organisms that were apparent in the comparison of detection of isolates were also present, although none of the differences in detection of episodes of bacteremia was statistically significant.

TABLE 1. Recovery of probable pathogens from 6,636 blood culture sets consisting of BacT/Alert FAN and ESP 80A bottles

Organism	No. of probable pathogens recovered by the following:				P^a
	BacT/Alert FAN only	ESP 80A only	Both bottles	Total	
Staphylococcus aureus	19	6	28	53	0.02
Coagulase-negative staphylococci	9	4	28	41	0.27
Streptococcus pneumoniae	15	22	36	73	0.32
Group B streptococci	1	2	13	16	1.0
Other beta-hemolytic streptococci[b]	1	3	1	5	0.62
Enterococcus spp.	1	7	9	17	0.08
Enterobacteriaceae	7	8	32	47	1.0
Pseudomonas aeruginosa	1	0	8	9	1.0
Haemophilus influenzae	0	0	2	2	
Acinetobacter spp.	5	3	5	13	0.72
Neisseria meningitidis	1	1	3	5	0.48
Candida or *Torulopsis*	7	3	10	20	0.34
Other[c]	2	3	2	7	1.0
Total	69	62	177	308	0.60

[a] McNemar's test.
[b] Includes three group A and two group G beta-hemolytic streptococcal isolates.
[c] Includes one *Streptococcus intermedius*, two *Bacillus cereus*, one *Pseudomonas putida*, one CDC DF-3, one *Stenotrophomonas maltophilia*, and one *Staphylococcus saccharolyticus* isolate.

The effect of antibiotic therapy on failure to detect episodes of bacteremia was examined more closely. A review of the episodes of *Staphylococcus aureus* bacteremia revealed that 5 of the 10 episodes that were detected only by BacT/Alert FAN were among patients receiving antistaphylococcal antibiotics when the discrepant sample for culture was obtained, whereas 1 of the 5 episodes that were detected only by ESP 80A was in a patient receiving antistaphylococcal antibiotics. Of the 48 episodes of *Streptococcus pneumoniae*, group A streptococcal, or enterococcal bacteremia that were detected by only one system, two episodes that were detected only by BacT/Alert FAN and four episodes that were detected only by ESP 80A occurred in patients receiving antibiotics active against these organisms when the sample for culture was obtained. Of the six patients with episodes of candidemia that were detected by only one system, only one episode, detected by BacT/Alert FAN, occurred in a patient receiving antifungal therapy when the blood samples for culture were obtained.

A total of 802 possible contaminants were detected; of these, 186 were detected by both systems, 334 were detected by ESP 80A only and 282 were detected by BacT/Alert FAN only ($P = 0.04$). The most common possible contaminants were coagulase-negative staphylococci, which accounted for 65.7% of the contaminants, and viridans group streptococci, which accounted for 11.7%.

The time to detection was compared for organisms that were isolated as single pathogens in both systems. Times to detection were short for both systems (Table 4). For ESP 80A the times by which 50 and 95% of probable pathogens were detected were 13.6 and 39.6 h, respectively, compared to 15.7 and

TABLE 2. Effect of antibiotic therapy on recovery of probable pathogens from 6,636 blood culture sets consisting of BacT/Alert FAN and ESP 80A bottles

Organism	No. of pathogens recovered from patients receiving antibiotics			*P* for patients receiving antibiotics[a]	No. of pathogens recovered from patients not receiving antibiotics			*P* for patients not receiving antibiotics[a]
	BacT/Alert FAN only	ESP 80A only	Both bottles		BacT/Alert FAN only	ESP 80A only	Both bottles	
Staphylococcus aureus	11	1	14	<0.01	8	5	14	NS
Coagulase-negative staphylococci	9	2	8	NS	0	2	20	NS
Streptococcus pneumoniae[b]	2	1	2	NS	13	21	33	NS
Group B streptococci	0	0	0	NS	1	2	13	NS
Other beta-hemolytic streptococci[c]	0	0	0	NS	1	3	1	NS
Enterococcus spp.	0	3	3	NS	1	4	6	NS
Enterobacteriaceae	1	2	15	NS	6	6	17	NS
Pseudomonas aeruginosa	1	0	7	NS	0	0	1	NS
Acinetobacter spp.	0	1	3	NS	5	2	2	NS
Neisseria meningitidis	1	0	1	NS	0	1	2	NS
Candida or *Torulopsis*	2	0	3	NS	5	3	7	NS
Other[d]	0	1	0	NS	2	2	4	NS
Total	27	11	56	0.02	42	51	120	NS

[a] McNemar's test. NS, not significant ($P > 0.05$).
[b] Data for one culture in which *Streptococcus pneumoniae* was detected in both bottles were excluded because information on antibiotic therapy was not available.
[c] Includes three group A and two group G beta-hemolytic streptococcal isolates.
[d] Includes two *Haemophilus influenzae*, one *Streptococcus intermedius*, two *Bacillus cereus*, one *Pseudomonas putida*, one CDC DF-3, one *Stenotrophomonas maltophilia*, and one *Staphylococcus saccharolyticus* isolate.

46.3 h, respectively, for BacT/Alert FAN. Although statistically significant differences were present for a number of individual species, the magnitudes of the differences were small and not clinically significant for most species. For five cultures the BacT/Alert FAN signaled a positive result but no organisms were detected by Gram staining at that time. These bottles were reincubated and a positive result was subsequently signaled again. A Gram stain performed at this time revealed organisms, suggesting that the first signal was valid. However, according to the study protocol, the time to detection for these cultures was recorded as the time to the signal that was confirmed by Gram staining.

The yield from each bottle in the blood culture sets that included an ESP 80N (anaerobic) bottle in addition to the BacT/Alert FAN and ESP 80A bottles is indicated in Table 5. Also indicated are the organisms recovered uniquely by each of the bottles and hypothetical yields from each of the possible two-bottle combinations. Note that the blood volume inoculated into the ESP 80N bottle was not measured, although personnel obtaining the blood samples were instructed to allocate blood equally among the different bottles that were

TABLE 3. Episodes of bacteremia or fungemia detected by BacT/Alert FAN and ESP 80A bottles from 6,636 blood culture sets

Organism	No. of episodes of bacteremia or fungemia detected by the following:				*P*[a]
	BacT/Alert FAN only	ESP 80A only	Both bottles	Total	
Staphylococcus aureus	10	5	19	34	0.30
Coagulase-negative staphylococci	3	2	21	26	1.0
Streptococcus pneumoniae	16	22	35	73	0.42
Group B streptococci	1	2	13	16	1.0
Other beta-hemolytic streptococci[b]	0	3	1	4	0.25
Enterococcus spp.	1	7	9	17	0.08
Enterobacteriaceae	5	7	28	40	0.78
Pseudomonas aeruginosa	1	0	5	6	1.0
Haemophilus influenzae	0	0	2	2	
Acinetobacter spp.	2	3	2	7	1.0
Neisseria meningitidis	1	1	3	5	0.48
Candida or *Torulopsis*	5	1	6	12	0.22
Other[c]	1	3	2	6	0.62
Total	46	56	146	248	0.37

[a] McNemar's test.
[b] Includes three group A and one group G beta-hemolytic streptococcal isolate.
[c] Includes one *Streptococcus intermedius*, one *Bacillus cereus*, one *Pseudomonas putida*, one CDC DF-3, one *Stenotrophomonas maltophilia*, and one *Staphylococcus saccharolyticus* isolate.

TABLE 4. Time to detection of probable pathogens isolated from both BacT/Alert FAN and ESP 80A bottles

Organism	No. of isolates	Time (h) to detection				*P*[a]
		BacT/Alert FAN		ESP 80A		
		Median	Range	Median	Range	
Staphylococcus aureus	25	15.5	9.7–23.0	14.4	8.6–52.8	0.20
Coagulase-negative staphylococci	25	23.3	16.5–50.4	19.6	13.6–81.6	0.002
Streptococcus pneumoniae	35	14.8	7.3–18.2	13.2	6.2–17.6	<0.001
Group B streptococci	12	12.2	8.7–14.0	10.6	6.8–14.0	0.01
Enterococcus spp.	5	34.8	10.8–52.8	16.4	6.2–144	0.50
Enterobacteriaceae	27	12.0	7.8–29.8	11.2	6.4–91.2	0.003
Pseudomonas aeruginosa	6	18.7	15.8–36.0	16.6	10.4–17.4	0.03
Acinetobacter spp.	5	11.3	8.6–14.2	9.6	6.4–10.6	0.04
Neisseria meningitidis	3	23.2	22.3–23.7	12.2	11.2–19.0	0.11
Candida or *Torulopsis*	10	29.0	21.3–38.3	34.7	15.6–60.0	0.10
Other[b]	4	16.4	10.3–32.3	18.7	10.0–96.0	1.0
Total	157	15.7	7.3–52.8	13.6	6.2–144.0	<0.001

[a] Wilcoxon signed rank test.
[b] Includes one group G streptococcus, one *Bacillus cereus*, one *Pseudomonas putida*, and one *Haemophilus influenzae* isolate.

TABLE 5. Pathogens recovered from three-bottle blood culture sets[a]

Organism	No. of pathogens recovered			No. of pathogens recovered only from the following:			No. of pathogens from two-bottle combinations			Total no. of pathogens recovered
	BacT/Alert FAN	ESP 80A	ESP 80N	BacT/Alert FAN	ESP 80A	ESP 80N	BacT/Alert FAN and ESP 80A	BacT/Alert FAN and ESP 80N	ESP 80A and ESP 80N	
Staphylococcus aureus	34	27	30	8	2	3	38	39	33	41
Coagulase-negative staphylococci	14	14	12	1	1	0	16	15	15	16
Streptococcus pneumoniae	44	48	42	6	12	4	62	54	60	66
Group B streptococcus	8	10	7	0	2	0	10	8	10	10
Other beta-hemolytic streptococci[b]	2	4	6	1	0	2	5	7	6	7
Enterococcus spp.	4	8	8	1	2	3	9	10	11	12
Enterobacteriaceae	19	19	22	2	5	4	25	24	27	29
Pseudomonas aeruginosa	6	6	6	0	0	0	6	6	6	6
Haemophilus influenzae	1	1	1	0	0	0	1	1	1	1
Acinetobacter spp.	10	7	2	6	3	0	13	10	7	13
Neisseria meningitidis	4	4	0	1	1	0	5	4	4	5
Anaerobes[c]	0	1	6	0	1	6	1	6	7	7
Candida or *Torulopsis*	13	12	4	4	2	0	16	14	12	16
Other[d]	0	2	0	0	2	0	2	0	2	2
Total	159	163	146	30	33	22	209	198	201	231

[a] Results are based on 4,472 blood culture sets that included three bottles.
[b] Includes five group A and two group G beta-hemolytic streptococcal isolates.
[c] Includes one *Bacteroides* sp. (not *Bacteroides fragilis*), three fusobacteria, 2 *Peptostreptococcus micros*, and 1 *Staphylococcus saccharolyticus* isolate.
[d] Includes one *Streptococcus intermedius* and one CDC DF-3 isolate.

filled. A total of 231 pathogens were detected by one or more bottles of the three-bottle sets. Of these, 163 (70.6%) were detected by the ESP 80A bottle, 159 (68.8%) were detected by the BacT/Alert FAN bottle, and 146 (63.2%) were detected by the ESP 80N bottle. Organisms for which individual bottles showed special value were *Staphylococcus aureus* (8 isolates recovered only by BacT/Alert FAN), *Streptococcus pneumoniae* (12 isolates recovered only by ESP 80A), and anaerobes (6 isolates recovered only by ESP 80N. The yields from two-bottle combinations were 209 (90.5%) isolates from ESP 80A plus BacT/Alert FAN, 201 (87.0%) isolates from ESP 80A plus ESP 80N, and 198 (85.7%) isolates from FAN and ESP 80N.

The rate of false-positive signals was 0.13% (9 of 6,636) for both systems. False-negative signals were also rare. In three instances organisms were detected in a terminal subculture of an aliquot from an ESP 80A bottle performed because the result for the companion BacT/Alert FAN bottle was positive. The organisms recovered from the ESP 80A bottle in these instances were coagulase-negative staphylococcus, gamma-hemolytic streptococcus, and *Propionibacterium* species, each of which was detected in one bottle. Only the coagulase-negative staphylococcus matched the organism isolated from the companion BacT/Alert FAN bottle. It was thought that all three organisms were possible contaminants. There were no false-negative signals from BacT/Alert FAN.

DISCUSSION

In this study we compared the BacT/Alert system using the 40-ml FAN aerobic bottle with the Difco ESP system using the 80-ml 80A aerobic bottle for the detection of bloodstream pathogens in pediatric patients. Although the overall rate of detection of pathogens was not statistically significantly different, it was possible to discern differences in the detection of selected species. The FAN bottle was superior for the recovery of *Staphylococcus aureus*, detecting significantly more isolates. An excess of five episodes of staphylococcal bacteremia were detected only by BacT/Alert FAN. It is likely that this reflects the better ability of BacT/Alert FAN to recover some organisms, especially staphylococci, from patients receiving antimicrobial therapy. In contrast, the ESP 80A bottle detected more episodes of bacteremia associated with *Streptococcus pneumoniae*, other streptococci, and enterococci, and this difference was unrelated to antibiotic therapy. The time to detection of the major bloodstream pathogens was remarkably short with both systems. The small difference in favor of the ESP 80A bottle was statistically significant but not clinically significant.

The FAN bottle which was used with the BacT/Alert system in this study is formulated with charcoal and Fuller's earth to enhance growth, partly by binding antimicrobial agents. BacT/Alert FAN did recover more pathogens than ESP 80A from patients who were receiving antibiotics at the time that the blood sample for culture was obtained. No significant difference in the recovery of probable pathogens was noted for patients who were not receiving antibiotics. Overall, the recovery of probable pathogens and the detection of episodes of bacteremia were not statistically significantly different between the two systems. A disadvantage of the FAN bottle was that the particulate matter in the bottle complicated the reading of the Gram staining results for positive bottles, although this problem became minimal as technologists mastered techniques for separating the particulate matter from the blood film being examined.

The rate of blood culture contamination in this study was distressingly high. It is important to recognize that under the criteria used for classifying organisms in this study as probable pathogens or possible contaminants, organisms that are often contaminants had to be isolated from more than one culture in order to be considered probable pathogens. These criteria may have resulted in improper classification of organisms causing some episodes of true bacteremia as possible contaminants, since it is not uncommon for only one blood sample for culture to be obtained from pediatric patients. Nevertheless, even if some such misclassifications are taken into account, the rate of

contamination was high. The procedures used for skin preparation during the study period involved cleansing with povidone iodine and ethanol. A recent study showed a decreased rate of blood culture contamination when 2% tincture of iodine was used compared to that when povidone iodine and ethanol were used (12). It is possible that use of this method of skin preparation could lower the rate of contamination. We are currently evaluating methods to decrease the rate of blood culture contamination. Proper skin decontamination is of the utmost importance in using systems that are highly supportive of the growth of organisms that are normal flora of the skin.

Several other aspects of the design of this study are of note. First, sets were included in the study only if any difference in the allocation of blood between the study bottles was within the predefined criterion of twofold. This criterion was met for 85% of the sets submitted, even though the blood used for the large majority of the sets was not drawn by professional phlebotomists. Second, delays in transport and entry into the blood culture instrument were minimal since all blood samples were obtained in the same building as the laboratory and laboratory personnel were always available to place blood culture bottles on the instruments. Third, no minimal blood volume was required. Although an educational campaign was mounted to stress the importance of blood volume for maximizing the recovery of bloodstream pathogens, it was also recognized that difficulties in obtaining blood from pediatric patients would unavoidably result in the submission of occasional samples for culture with very small blood volumes. These were not excluded from the study in order to simulate conditions of actual use as closely as possible.

The question of whether an anaerobic bottle is required when culturing pediatric blood samples is controversial (2, 15, 16, 20). Although the primary aim of this study was not to evaluate the utility of an anaerobic bottle, we did accumulate data that are relevant to this question. In a substantial proportion of blood culture sets analyzed, an anaerobic bottle (ESP 80N) in addition to the two aerobic bottles was included, and thus, we were able to compare the hypothetical yield from each of the three possible two-bottle combinations. Although the difference was small, the highest hypothetical yield was from the combination of two aerobic bottles. However, that combination missed six of the seven episodes of anaerobic bacteremia. It appears that there is a trade-off, with the anaerobic bottle needed for recovery of anaerobes but resulting in a lower yield in the total number of aerobes recovered. Selective use of anaerobic bottles for situations in which anaerobic bacteremia is likely is a logical approach, but successful application in a real-life situation has not yet been documented.

Technologists in the laboratory found both systems easy to work with. Neither instrument had any serious problems causing downtime during the study period. Bottle entry and removal were straightforward with both systems. Daily quality control with both systems was nonburdensome, requiring approximately 4 min with BacT/Alert and 20 s with ESP. The macro functions that were included with the BacT/Alert software were time saving, and data entry checks were useful in preventing errors in specimen data entry. There were no mechanical problems with the BacT/Alert instrument, while there were some minor problems with sliders on the drawers of the ESP instrument that resulted in service calls, but these did not seriously compromise operation of the system.

In summary, both the BacT/Alert system with the FAN bottle and the ESP system with the 80A bottle achieved comparable overall recoveries of pediatric bloodstream pathogens. With both systems, the time to detection was dramatically shortened compared to that with conventional blood culture systems. BacT/Alert FAN is particularly advantageous for the recovery of staphylococci and may allow for the increased detection of bloodstream pathogens from patients receiving antibiotics. The ESP 80A bottle is advantageous for the isolation of streptococci and enterococci. Because of the infrequency of *Haemophilus influenzae* and *Neisseria meningitidis* bacteremia during the study period, the study was not able to evaluate the performance of the systems for those potentially important pediatric pathogens. With this caveat in mind, both systems can be enthusiastically recommended as aerobic blood culture systems for pediatric patients.

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REFERENCES

1. **Cockerill, F. R., III, C. A. Torgerson, G. S. Reed, E. A. Vetter, A. L. Weaver, J. C. Dale, G. D. Roberts, N. K. Henry, D. M. Ilstrup, and J. E. Rosenblatt.** 1996. Clinical comparison of Difco ESP, Wampole Isolator, and Becton Dickinson Septi-Chek aerobic blood culturing systems. J. Clin. Microbiol. **34:**20–24.
2. **Dunne, W. M., Jr., J. Tillman, and P. L. Havens.** 1994. Assessing the need for anaerobic medium for the recovery of clinically significant blood culture isolates in children. Pediatr. Infect. Dis. J. **13:**203–206.
3. **Hellinger, W. C., J. J. Cawley, S. Alvarez, S. F. Hogan, W. S. Harmsen, D. M. Ilstrup, and F. R. Cockerill III.** 1995. Clinical comparison of the Isolator and BacT/Alert aerobic blood culture systems. J. Clin. Microbiol. **33:**1787–1790.
4. **Krisher, K. K., D. R. Whyburn, and F. E. Koepnick.** 1993. Comparison of the BacT/Alert pediatric blood culture system, Pedi-BacT, with conventional culture using the 20-milliliter Becton-Dickinson supplemented peptone broth tube. J. Clin. Microbiol. **31:**793–797.
5. **Morello, J. A., C. Leitch, S. Nitz, J. W. Dyke, M. Andruszewski, G. Maier, W. Landau, and M. A. Beard.** 1994. Detection of bacteremia by Difco ESP blood culture system. J. Clin. Microbiol. **32:**811–818.
6. **Nolte, F. S., J. M. Williams, R. C. Jerris, J. A. Morello, C. D. Leitch, S. Matushek, L. D. Schwabe, F. Dorigan, and F. E. Kocka.** 1993. Multicenter clinical evaluation of a continuous monitoring blood culture system using fluorescent-sensor technology (BACTEC 9240). J. Clin. Microbiol. **31:**552–557.
7. **Pohlman, J. K., B. A. Kirkley, K. A. Easley, B. A. Basille, and J. A. Washington.** 1995. Controlled clinical evaluation of BACTEC Plus aerobic/F and BacT/Alert aerobic FAN bottles for detection of bloodstream infections. J. Clin. Microbiol. **33:**2856–2858.
8. **Rohner, P., B. Pepey, and R. Auckenthaler.** 1996. Comparative evaluation of BACTEC Aerobic Plus/F and Septi-Chek release blood culture media. J. Clin. Microbiol. **34:**126–129.
9. **Schwabe, L. D., R. B. Thomson, Jr., K. K. Flint, and F. P. Koontz.** 1995. Evaluation of BACTEC 9240 blood culture system by using high-volume aerobic resin media. J. Clin. Microbiol. **33:**2451–2453.
10. **Smith, J. A., E. A. Bryce, J. H. Ngui-Yen, and F. J. Roberts.** 1995. Comparison of BACTEC 9240 and BacT/Alert blood culture systems in an adult hospital. J. Clin. Microbiol. **33:**1905–1908.
11. **Snyder, J. W., and S. K. Lude.** 1996. Comparison of BacT/Alert FAN medium with BACTEC NR660 plus 26A medium. J. Clin. Microbiol. **34:**1327–1329.
12. **Strand, C. L., R. R. Wajsbort, and K. Sturmann.** 1993. Effect of iodophor vs iodine tincture skin preparation on blood culture contamination rate. JAMA **269:**1004–1006.
13. **Thorpe, T. C., M. L. Wilson, J. E. Turner, J. L. DiGuiseppi, M. Willert, S. Mirrett, and L. B. Reller.** 1990. BacT/Alert: an automated colorimetric microbial detection system. J. Clin. Microbiol. **280:**1608–1612.
14. **Weinstein, M. P., S. Mirrett, L. G. Reimer, M. L. Wilson, S. Smith-Elekes, C. R. Chuard, K. L. Joho, and L. B. Reller.** 1995. Controlled evaluation of BacT/Alert standard aerobic and FAN aerobic blood culture bottles for detection of bacteriemia and fungemia. J. Clin. Microbiol. **33:**978–981.
15. **Weisse, M. E., J. W. Bass, and L. M. Young.** 1992. Pediatric blood culture: comparison of yields using aerobic, anaerobic and hypertonic media. Pediatr. Infect. Dis. J. **11:**123–125.
16. **Weisse, M. E.** 1994. Utility of anaerobic medium in pediatric blood cultures. Pediatr. Infect. Dis. J. **13:**837–838. (Letter.)
17. **Welby, P. L., D. S. Keller, and G. A. Storch.** 1995. Comparison of the automated Difco ESP blood culture system with the biphasic BBL Septi-Chek system in pediatric patients. J. Clin. Microbiol. **33:**1084–1088.
18. **Wilson, M. L., M. P. Weinstein, L. G. Reimer, S. Mirrett, and L. B. Reller.**

1992. Controlled comparison of the BacT/Alert and BACTEC 660/730 nonradiometric blood culture systems. J. Clin. Microbiol. **30:**323–329.

19. **Wilson, M. L., M. P. Weinstein, S. Mirrett, L. G. Reimer, R. J. Feldman, C. R. Chuard, and L. B. Reller.** 1995. Controlled evaluation of BacT/Alert standard anaerobic and FAN anaerobic blood culture bottles for the detection of bacteremia and fungemia. J. Clin. Microbiol. **33:**2265–2270.
20. **Zaidi, A. K. M., A. L. Knaut, S. Mirrett, and L. B. Reller.** 1995. Value of routine anaerobic blood cultures for pediatric patients. J. Pediatr. **127:**263–268.
21. **Zwadyk, P., Jr., C. L. Pierson, and C. Young.** 1994. Comparison of Difco ESP and Organon Teknika BacT/Alert continuous-monitoring blood culture systems. J. Clin. Microbiol. **32:**1273–1279.