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Controlled Clinical Laboratory Comparison of BACTEC Plus Aerobic/F Resin Medium with BacT/Alert Aerobic FAN Medium for Detection of Bacteremia and Fungemia

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Blood specimens collected from adult patients with suspected sepsis in four medical centers were inoculated into BACTEC Plus/F and BacT/Alert FAN aerobic culture bottles. Both bottles of 7,401 bottle pairs contained the prescribed blood volume of 8 to 12 ml. Bottles were incubated in their respective instruments for a standard 7-day protocol or until the instruments signaled that they were positive. A total of 720 isolates that were judged to represent true infections were recovered from 338 patients; 451 isolates were recovered from both bottles, 143 were recovered from only the Plus/F bottle, and 126 were recovered from only the FAN bottle (*P* was not significant). Although more *Histoplasma capsulatum* isolates were recovered from Plus/F bottles ($P < 0.005$), there were no other statistically significant differences in recovery rates of individual species or groups of organisms between the two systems. Of 329 monomicrobic patient septic episodes, 244 episodes were detected by both blood culture systems, 40 were detected only by the BACTEC system, and 45 were detected only by the BacT/Alert system (*P* was not significant). There was no significant difference between the two systems in the detection of septic episodes among patients receiving antibiotic therapy at the time of blood cultures. Of the cultures found to be positive within the first 72 h of incubation, detection was on average earlier by the BACTEC system (16.9 h) than by the BacT/Alert system (18.7 h). Larger differences in average time to detection were seen with streptococci (10.7 h by the BACTEC system and 17.9 h by the BacT/Alert system) and yeasts (an average of 29.4 h by the BacT/Alert system versus 37.2 h by the BACTEC system). With the exception of the differences noted above, BACTEC Plus/F aerobic resin and BacT/Alert aerobic FAN blood culture bottles were comparable in their abilities to recover aerobic and facultative organisms.

The prompt detection of bacteremia and fungemia continues to be one of the most important responsibilities of the clinical microbiology laboratory. Microbiologists are able to choose among several manual approaches to performing blood cultures or three currently available automated continuous monitoring instrument systems, the BACTEC 9000 system (8, 9, 11), the Difco ESP system (6, 20), or the Organon Teknika BacT/Alert system (11, 12, 19). The instrument systems offer several choices of media for the recovery of aerobic or anaerobic organisms. In addition, two of the instrument systems offer media containing particles intended for adsorption of antimicrobial agents from the blood of patients receiving therapy, i.e., BACTEC Plus/F resin medium and BacT/Alert FAN medium (9, 13, 18). Previous studies have demonstrated somewhat greater yields of some organisms as well as faster recoveries of some species from bottles containing either resins or Ecosorb (a mixture of charcoal and Fuller's earth) compared to those for media formulations without the neutralization particles (1, 2, 4, 9, 13, 14, 16, 18). This study has compared directly the performance of the BACTEC Plus/F aerobic resin medium and the BacT/Alert aerobic FAN medium for recovery of microorganisms from patients in four geographically separate medical centers.

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MATERIALS AND METHODS

Patient populations. The four medical centers that conducted this study range from primary care teaching hospitals to large, tertiary care facilities. All four centers care for appreciable numbers of transplant, immunosuppressed, and human immunodeficiency virus-positive patients, as well individuals presenting with common community-acquired infections.

Collection of blood for culture. Blood for culture was obtained from adult patients in each of the four hospitals (Barnes Hospital, St. Louis, Mo.; Duke University Medical Center, Durham, N.C.; Robert Wood Johnson University Hospital, New Brunswick, N.J.; and University Hospital, San Antonio, Tex.). All blood cultures were performed on the basis of the physicians' requests as part of routine patient care. The site of phlebotomy was prepared with povidone iodine prior to withdrawing approximately 20 ml of venous blood by using sterile needles and syringes. Blood culture "kits" were prepared for the purposes of the study; each kit contained the culture bottles, skin decontamination supplies, the needle and syringe, and instructions for obtaining a blood culture (including the need to inoculate each bottle with 10 ml of blood for this protocol). Blood was inoculated directly into the BACTEC and BacT/Alert bottles at the bedside after decontaminating the rubber septum with 70% alcohol. Three of the study sites obtained 30 ml of blood for each culture and divided it equally between the two study bottles and an anaerobic bottle standard for that institution. One site used only the two aerobic study bottles for routine cultures. The order of inoculation of the bottles was determined by paper stickers affixed to the bottles that indicated "inoculate first," "inoculate second," and "inoculate third." The BACTEC bottles were inoculated first during the first half of the study, and the BacT/Alert bottles were inoculated first during the second half of the study. The

TABLE 1. Comparative yields of clinically important bacteria and fungi in BACTEC Plus/F and BacT/Alert FAN aerobic culture bottles

Microorganism	No. of isolates recovered from:			P
	Both bottles	BACTEC Plus/F only	BacT/Alert FAN only	
Gram-positive cocci				
Staphylococcus aureus	125	23	18	NS[a]
Coagulase-negative staphylococci[b]	79	15	20	NS
Enterococcus faecalis	18	16	9	NS
Other *Enterococcus* spp.[c]	6	5	3	NS
Streptococcus pneumoniae	12	2	6	NS
Hemolytic streptococci[d]	11	3	1	NS
Viridans group streptococci[e]	16	0	1	NS
Gram-positive bacilli[f]	1	3	0	NS
Gram-negative bacilli				
Escherichia coli	42	12	11	NS
Klebsiella spp.[g]	25	3	4	NS
Enterobacter cloacae	14	4	2	NS
Enterobacter aerogenes	7	0	2	NS
Other members of the family *Enterobacteriaceae*[h]	13	4	4	NS
Pseudomonas aeruginosa	22	9	9	NS
Other[i]	14	7	4	NS
Anaerobic bacteria[j]	1	2	5	NS
Fungi				
Candida albicans	23	16	12	NS
Cryptococcus neoformans	9	0	3	NS
Candida glabrata	9	2	9	NS
Candida tropicalis	3	3	3	NS
Histoplasma capsulatum	0	10	0	<0.005
Exophiala jeanselmei	1	4	0	NS
All microorganisms	451	143	126	NS

[a] NS, not significant ($P > 0.05$).
[b] Includes 7 *Staphylococcus epidermidis*, 2 *Staphylococcus warneri*, 1 *Staphylococcus haemolyticus*, and 104 isolates that were not identified to the species level.
[c] Includes 12 *Enterococcus faecium* and 2 isolates not identified to the species level.
[d] Includes 6 group B, 5 group A, and 4 group G beta-hemolytic streptococci.
[e] Includes 6 *Streptococcus sanguis*, 1 *Streptococcus mitis*, 1 *Streptococcus salivarius*, and 9 viridans group streptococci not identified to the species level.
[f] Includes 2 *Corynebacterium jeikeium*, 1 *Lactobacillus* spp., and 1 *Listeria* spp.
[g] Includes 28 *Klebsiella pneumoniae* and 4 *Klebsiella oxytoca.*
[h] Includes 5 *Serratia marcescens*, 4 *Proteus mirabilis*, 3 *Citrobacter freundii*, 3 *Morgella morganii*, 2 *Citrobacter diversus*, 2 *Yersinia* spp., 1 *Pantoea agglomerans*, and 1 *Proteus vulgaris.*
[i] Includes 5 *Acinetobacter baumanii*, 5 *Burkholderia cepacia*, 4 *Pseudomonas* spp., 3 *Burkholderia gladioli*, 2 *Aeromonas hydrophila*, 2 *Acinetobacter lwoffii*, 1 *Alcaligenes* spp., 1 *Pseudomonas stutzeri*, 1 *Stentrophomonas maltophilia*, 1 *Haemophilus influenzae.*
[j] Includes 2 *Bacteroides fragilis*, 2 *Clostridium perfringens*, 2 *Clostridium septicum*, 1 *Clostridium clostridiforme*, and 1 *Prevotella* spp.

anaerobic bottles were inoculated last throughout the study. Inoculated bottles were transported promptly to the laboratories for processing.

Laboratory processing. Upon receipt in the laboratories, the cultures were accessioned according to the laboratories' standard protocols. Each study bottle was compared visually with like bottles containing measured volumes of liquid as standards to estimate the adequacy of the blood volume. Bottles that contained approximately 8 to 12 ml of blood were considered acceptable and were included in the study. Those that contained more or less than the prescribed volume were considered noncompliant and were processed for the benefit of the patient, but the results for those bottles were not included in the main analysis of the study data. Prior to incubation, the BacT/Alert bottles were transiently vented following decontamination of the septum with an airway venting unit provided by the manufacturer. BacT/Alert bottles that were inadvertently not vented were considered noncompliant and the results for those bottles were excluded from the data analysis. However, isolates from noncompliant sets were used in some instances in the episode analysis (see below) to determine whether isolates of the same species represented a new infection or a continuing episode.

All bottles were examined for macroscopic evidence of growth at the time of receipt to enable processing of visually positive cultures without placement in the instruments. All other bottles were placed in their respective instruments for incubation and monitoring according to the manufacturers' recommendations. All blood culture bottles were incubated by using a 7-day incubation protocol with both instruments at all four study sites. The BACTEC 9000 instruments at all four sites used software version 3.04, while the BacT/Alert instruments all used software version C.02. Bottles indicated as positive by the instruments were removed from the incubation units, and an aliquot of the blood-broth mixture was removed aseptically with a needle and syringe for initial Gram staining. Based on the Gram stain results, aliquots of the bottles were subcultured onto appropriate media and were incubated by standard procedures. All isolates were identified to the species level whenever possible by standard methodology. Each positive blood culture bottle was processed independently of its companion study bottle; i.e., no Gram stains or subcultures were performed unless it was signaled as positive by the instrument. A terminal blind subculture onto chocolate agar incubated in 5 to 7% CO_2 was performed at the conclusion of the 7-day incubation period for all study bottles if the companion study bottle was found to be positive during the study period. The time of initial incubation and the actual time of first indication of positivity were recorded for each positive bottle. A record of all false-positive instrument signals (i.e., bottles that were smear and subculture negative after instrument signaling) was maintained.

Clinical assessment of blood culture isolates. All bacterial and fungal isolates were reviewed to determine whether they had caused the septic episode that had prompted the collection of blood for blood culture. They were judged as either significant, indeterminate, or insignificant (contaminant) on the basis of published criteria (15). In addition, if the patient was receiving antimicrobial therapy at the time of blood culture, a determination of whether the agent was appro-

TABLE 2. Episodes of monomicrobial bacteremia or fungemia detected by BACTEC Plus/F and BacT/Alert FAN aerobic culture bottles

Cause of episode	No. of episodes detected by:			P
	Both bottles	BACTEC Plus/F only	BacT/Alert FAN only	
Gram-positive cocci				
S. aureus	66	9	9	NS[a]
Coagulase-negative staphylococci	43	4	5	NS
E. faecalis	6	1	3	NS
E. faecium	2	0	0	NS
S. pneumoniae	8	1	2	NS
Hemolytic streptococci	6	1	0	NS
Viridans group streptococci	7	0	0	NS
Gram-positive bacilli	2	1	0	NS
Gram-negative bacilli				
E. coli	29	7	7	NS
Klebsiella spp.	12	1	2	NS
E. cloacae	7	0	2	NS
Other members of the family *Enterobacteriaceae*	10	2	1	NS
P. aeruginosa	14	3	3	NS
Other	4	1	4	NS
Anaerobic bacteria	2	0	2	NS
Fungi				
C. albicans	16	5	1	NS
C. neoformans	3	0	0	NS
C. glabrata	2	1	4	NS
C. tropicalis	3	0	0	NS
H. capsulatum	0	2	0	NS
E. jeanselmei	1	0	0	NS
Total episodes	244	40	45	NS

[a] NS, not significant ($P > 0.05$).

TABLE 3. Comparative yields of clinically important bacteria and fungi in BACTEC Plus/F and BacT/Alert FAN aerobic culture bottles from patients receiving antibiotic therapy at the time of blood culture

Microorganism	No. of isolates recovered from:			*P*
	Both bottles	BACTEC Plus/F only	BacT/Alert FAN only	
Gram-positive cocci				
S. aureus	39	15	7	NS[a]
Coagulase-negative staphylococci	24	7	7	NS
E. faecalis	0	6	4	NS
E. faecium	1	1	0	NS
S. pneumoniae	0	0	2	NS
Hemolytic streptococci	2	1	1	NS
Viridans group streptococci	6	0	0	NS
Gram-negative bacilli				
E. coli	5	6	1	NS
Klebsiella spp.	4	0	0	NS
E. cloacae	6	2	1	NS
E. aerogenes	4	0	0	NS
Other members of the family *Enterobacteriaceae*	3	2	0	NS
P. aeruginosa	14	5	3	NS
Other	2	6	2	NS
Fungi				
C. albicans	9	6	8	NS
C. neoformans	6	0	1	NS
C. glabrata	4	0	2	NS
C. tropicalis	2	3	3	NS
H. capsulatum	0	2	0	NS
All microorganisms[b]	132	62	43	NS

[a] NS, not significant ($P > 0.05$).
[b] For some species with only a single isolate, data were not depicted separately but were included in the total.

priate for (active against) the patient's isolate was made. Some patients were found to have more than one positive culture during the course of the study. An episode was defined as beginning with the first positive blood culture and ending when 7 days passed without another positive blood culture with the same organism, regardless of whether other blood samples for culture were obtained in the intervening period. If a different organism was isolated within 72 h of isolation of the first isolate, a polymicrobial infection was considered to be present, whereas if a different organism was recovered more than 72 h later, it was considered to represent a new episode. The criterion of a 72-h interval prior to a new episode is based in large part on the similar time that has been used by the Centers for Disease Control and Prevention to define a new (i.e., nosocomial) bacteremia (3).

Data analyses. The information that was recorded for each study culture included (i) the adequacy of blood volume of all bottles, (ii) for blood culture sets with at least one positive bottle, which bottle(s) was positive, (iii) how the bottles were found to be positive (macroscopic evidence of growth, positive instrument signal, terminal subculture), (iv) the number of hours required for each positive culture signal in each system, (v) the identity of each microbial isolate, (vi) whether each isolate was clinically significant or insignificant, (vii) whether antimicrobial therapy was being administered at the time of blood culture and whether it was appropriate, and (viii) the definition of septic episodes for patients with more than one positive culture. The modified chi-square test described by McNemar (7) was used to examine differences observed between the performance of the two culture bottles.

RESULTS

A total of 12,067 blood specimens were collected from patients in the four participating medical centers during the study period. All protocol criteria were met for 7,401 bottle pairs; 1,030 (13.9%) of these cultures yielded growth of 1,152 bacteria or fungi. A total of 720 (62.5%) of these from 337 patients were isolates deemed to be clinically significant. A total of 398 isolates (34.5%) were judged to be not clinically significant, and 34 isolates (3%) were of unknown clinical significance.

The comparative yields of bacteria and fungi from the two aerobic culture bottles are indicated in Table 1. Of the 720 clinically important isolates, 451 (62.6%) were recovered from both bottles, 143 (19.9%) were recovered only from the BACTEC Plus/F bottles, and 126 (17.5%) were recovered exclusively from the BacT/Alert FAN bottles (P = not significant). None of the observed differences in recovery of microorganisms between the two media reached statistical significance except for the dimorphic systemic fungus *Histoplasma capsulatum*, which was isolated only from the BACTEC Plus/F bottles ($P < 0.005$). However, the 10 isolates of *H. capsulatum* were recovered from only two patients in one of the study centers.

Table 2 depicts the recovery of clinically significant organisms in each blood culture system from patients according to septic episodes. While there was slightly greater detection of septic episodes due to certain species in one or the other medium, there were no statistically significant differences in the ability of either blood culture bottle or system to detect septic episodes. A number of patients were receiving antimicrobial therapy at the time that blood was collected for culture during the study. Table 3 details the recovery of various species of bacteria and fungi from patients who were receiving antimicrobial agents that had activity against the isolate recovered in their respective blood cultures. Of the 720 positive cultures, 237 (32.9%) were obtained from patients receiving antibiotics. There were no statistically significant differences in isolation rates between the two media for patients receiving antibiotics or differences in the detection of septic episodes among those patients by the two systems.

Table 4 indicates the comparative isolation rates of the 397 contaminant organisms, 92 (23.1%) of which were recovered from both bottles, 132 (33.2%) of which were found only in the BACTEC bottles, and 174 (43.7%) of which were recovered only in the BacT/Alert bottles ($P < 0.025$). While the overall

TABLE 4. Comparative yields of clinically unimportant (contaminant) bacteria in BACTEC Plus/F and BacT/Alert FAN aerobic culture bottles

Microorganism	No. of isolates recovered from:			*P*
	Both bottles	BACTEC Plus/F only	BacT/Alert FAN only	
Gram-positive cocci				
S. aureus	0	1	4	NS[a]
Coagulase-negative staphylococci	77	103	127	NS
Micrococcus spp.	0	2	3	NS
E. faecalis	5	3	4	NS
Viridans group streptococci	2	4	5	NS
Gram-positive bacilli				
Corynebacterium spp.	1	15	14	NS
Bacillus spp.	0	2	8	NS
Propionibacterium spp.	0	0	5	NS
Miscellaneous gram-negative bacilli	3	0	2	NS
All microorganisms[b]	92	132	174	<0.025

[a] NS, not significant ($P > 0.05$).
[b] For some species with only a single isolate, data were not depicted separately but were included in the total.

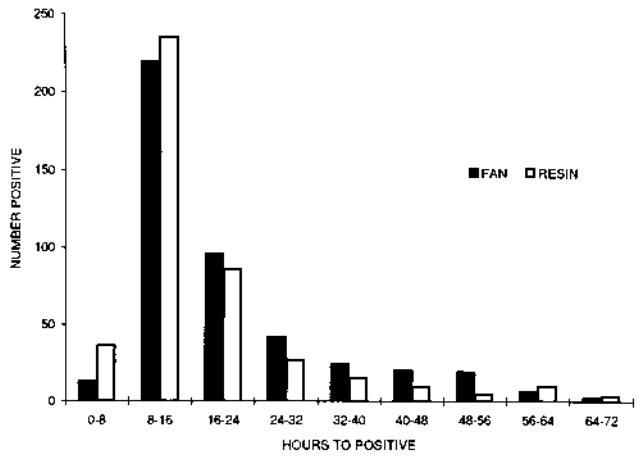

FIG. 1. Time to detection of clinically significant organisms recovered during the initial 72 h of incubation of BACTEC Plus/F aerobic (RESIN) and BacT/Alert aerobic (FAN) bottles.

contamination rate was higher in the BacT/Alert FAN bottles, there were no statistically significant differences in detection rates of individual contaminant species.

In general, all clinically significant organisms were detected very promptly by both systems (Fig. 1). The cumulative percentages of significant isolates detected by each system at 24, 48, and 72 h were 79.2, 90.5, and 94.2%, respectively, for the BACTEC system and 72.9, 92.0, and 98.0%, respectively, for the BacT/Alert system. The comparative speed of detection of various organisms is outlined in Table 5. Of the 451 organisms detected by both systems, 16 (3.5%) were detected at the same time, 267 (59.2%) were detected first in the BACTEC Plus/F bottles, and 168 (37.2%) were detected first in the BacT/Alert FAN bottles ($P < 0.001$). Growth of coagulase-negative staphylococci, *Enterococcus faecalis*, other *Enterococcus* species, *Streptococcus pneumoniae*, and hemolytic and viridans group streptococci most often was detected first by the BACTEC Plus/F bottles, whereas growth of *Candida albicans* and *Cryptococcus neoformans* more often was detected earlier in BacT/Alert FAN bottles.

For those organisms which were detected within the first 72 h by one or the other system and which eventually grew in both systems, overall, the BACTEC system provided somewhat faster detection of organisms (16.9 h) than the BacT/Alert system (18.8 h). As indicated in Table 6, for most organisms, the difference in time to detection between the two systems was small, usually 1 to 3 h. However, growth of *Enterococcus* spp. and viridans group streptococci was detected substantially faster by the BACTEC system than the BacT/Alert system (a mean of 7.7 to 10.3 h sooner), whereas growth of *C. albicans* was detected an average of 12.3 h sooner by the BacT/Alert system.

All cultures were incubated for a total of 7 days in this study. As reported earlier with the Bact/Alert (17), few significant isolates are detected past 5 days of incubation. Of the 720 positive cultures, only 2 BacT/Alert bottles (both containing *Bacteroides fragilis* isolates from the same patient) and 11 BACTEC bottles (three containing *Escherichia coli* isolates from three patients; three containing *Candida glabrata* isolates from one patient; and one each containing *C. albicans*, *S. aureus*, a coagulase-negative *Staphylococcus*, a *Lactobacillus* sp., and *Pseudomonas aeruginosa* from individual patients) yielded a clinically significant isolate beyond 5 days (120 h) of incubation. Three of these episodes (*E. coli*, *S. aureus*, and *Lactobacillus* sp.) were detected only on day 6 or 7; all were from patients having but a single positive blood culture. An additional 13 contaminants (3.3%; 5 in BacT/Alert bottles and 8 in BACTEC bottles) were encountered on days 6 and 7 of incubation.

Fourteen cultures (1.9%) were instrument positive in one medium but negative until terminal subculture at 7 days in the other medium. Of these falsely negative bottles, seven (1.0%) representing seven patients were missed with the BACTEC Plus/F medium, and seven (1.0%) representing four patients were missed with the BacT/Alert FAN medium. The Plus/F medium failed to detect five isolates of yeast (three *C. albicans*, one *C. glabrata*, and one *C. neoformans*), one *Enterococcus faecium* isolate, and one *Enterobacter cloacae* isolate. The FAN medium failed to detect one isolate of *S. aureus*, one isolate of *Staphylococcus haemolyticus*, one isolate of *C. albicans*, and four isolates of *Exophiala jeanselmei.*

A total of 59 of 8,033 (0.7%) adequately filled BACTEC Plus/F bottles yielded false-positive signals, and 35 of 8,944 (0.4%) compliant BacT/Alert FAN bottles yielded false-positive signals, as judged by negative Gram stain and subculture results.

DISCUSSION

The use of resin-containing media in earlier versions of the BACTEC instruments has at times been controversial, but

TABLE 5. Comparative speed of detection of clinically important bacteria and fungi when both BACTEC Plus/F and BacT/Alert aerobic culture bottles were positive

Microorganism	No. of isolates recovered from:			*P*
	BACTEC and BacT/Alert at same time	BACTEC earlier	BacT/Alert earlier	
Gram-positive cocci				
S. aureus	6	64	55	NS[a]
Coagulase-negative staphylococci	2	62	15	<0.001
E. faecalis	1	17	0	<0.001
Other *Enterococcus* spp.	0	6	0	<0.05
S. pneumoniae	0	12	0	<0.005
Hemolytic streptococci	2	9	0	<0.01
Viridans group streptococci	0	15	1	<0.005
Gram-negative bacilli				
E. coli	3	23	16	NS
Klebsiella spp.	1	15	9	NS
E. cloacae	0	7	7	NS
E. aerogenes	0	1	6	NS
Other members of the family *Enterobacteriaceae*	0	4	9	NS
P. aeruginosa	1	14	7	NS
Other	0	10	4	NS
Fungi				
C. albicans	0	2	21	<0.001
C. neoformans	0	0	9	<0.01
C. glabrata	0	2	7	NS
C. tropicalis	0	1	2	NS
All microorganisms	16	267	168	<0.001

[a] NS, not significant ($P < 0.05$).

TABLE 6. Mean time to detection of growth for clinically important microorganisms recovered within the first 72 h of incubation in both the BACTEC Plus/F and BacT/Alert aerobic culture bottles

Microorganism	Average time (h) to detection[a]			P
	BACTEC Plus/F	BacT/Alert FAN	No. of isolates	
Gram-positive cocci				
S. aureus	16.0	18.1	122	0.03
Coagulase-negative staphylococci	18.4	21.3	78	0.0001
Enterococcus spp.	11.6	21.9	23	0.0002
S. pneumoniae	10.3	12.8	12	0.0001
Hemolytic streptococci	8.3	12.9	11	0.03
Viridans group streptococci	11.7	19.4	16	0.0003
Gram-negative bacilli				
E. coli	13.1	14.4	42	NS[b]
Klebsiella spp.	12.7	11.8	25	NS
Enterobacter spp.	19.9	20.1	21	NS
Citrobacter spp.	21.9	15.1	4	NS
Other members of the family *Enterobacteriaceae*	32.3	20.0	8	NS
P. aeruginosa	14.7	16.4	21	NS
B. cepacia	31.3	31.9	4	NS
Acinetobacter spp.	9.9	16.8	5	NS
Fungi				
C. albicans	43.5	31.2	15	0.002
C. glabrata	21.8	22.1	4	NS
Overall avg time to positivity (h)	16.9	18.8		0.0003

[a] A total of 420 isolates were detected.
[b] NS, not significant ($P < 0.05$).

generally, resin media have increased the overall rate of isolation of organisms from patients receiving or not receiving antibiotics (1, 2, 4, 14, 16). It has been suggested that the greater yield of some organisms from patients not receiving antimicrobial therapy may be due to adsorption of nonspecific inhibitors present in human blood or due to lysis of leukocytes, thus liberating intracellular organisms (5, 14, 16). Similarly, it has been speculated that the addition of charcoal and Fuller's earth (Ecosorb) to create the BacT/Alert FAN medium may serve a similar function (13, 18). However, the FAN medium may also benefit from the more enriched brain heart infusion broth that is incorporated in both the aerobic and the anaerobic FAN bottles, as opposed to the soybean-casein digest broth contained in the standard BacT/Alert bottles (13, 18). Prior studies that have compared BACTEC resin media with non-resin-containing BACTEC media (1, 2, 5), FAN media with standard BacT/Alert media (13, 18), or BACTEC resin medium with standard BacT/Alert medium (9) have concluded that the media containing the neutralizing particles have improved the detection of some microbial species, particularly staphylococci, from patients receiving antimicrobial therapy at the time of culture. This study represents the first multilaboratory comparison of the aerobic BACTEC 9000 resin medium (Plus/F) with the aerobic BacT/Alert FAN medium. Similar to the recent single-center study of Pohlman et al. (9), the design of this study included equal funding by both instrument manufacturers and full disclosure of the data to the two sponsors as the study progressed. However, the sponsors were not allowed to update the instrument software or make any modifications to the instruments during the course of the study. The results of this study indicate that the two media and blood culture instruments yielded similar results except for those for *H. capsulatum*. The 10 isolations of *H. capsulatum* in BACTEC Plus/F medium from two patients in this study, however, do not provide sufficient data for any conclusion about the utility of either medium compared to established methods for the diagnosis of histoplasmosis.

While the two systems performed comparably in the recovery of clinically significant isolates, there was a greater tendency of the BacT/Alert FAN bottles to yield clinically insignificant (contaminant) organisms. There was a higher rate of FAN culture contamination with coagulase-negative staphylococci, *Bacillus* spp., and *Propionibacterium* spp., which resulted in a statistically significant overall greater rate of contaminant recovery from the FAN bottles ($P < 0.025$). This could have been due to the requirement to transiently vent the FAN bottles, but not the BACTEC Plus/F bottles. However, a previous study comparing unvented FAN aerobic bottles with standard BacT/Alert aerobic bottles also showed increased contaminants in the FAN bottles (13). Nevertheless, the requirement for venting FAN bottles increases the possibility of inadvertent needle sticks and provides the potential to introduce more contaminant bacteria.

The two media and instrument systems also were compared for the speed of recovery of clinically significant organisms. In general, gram-positive bacterial isolates were detected sooner by the BACTEC system than by the BacT/Alert system, whereas *C. albicans* and *C. neoformans* were detected significantly earlier by the BacT/Alert system. The BACTEC bottles resulted in earlier detection of all isolates combined than the BacT/Alert bottles ($P < 0.001$) (Table 5). However, the magnitude of the differences in time to detection of most organisms was often a matter of 1 to 3 h, which could not be considered a clinically significant interval. The most notable differences in the times to detection between the two instruments were with enterococci and viridans group streptococci, which were often detected 7 h or more sooner by the BACTEC instrument, and with *C. albicans* isolates, which were detected on average more than 12 h sooner by the BacT/Alert instrument.

An additional difference in the BACTEC Plus/F and BacT/Alert FAN aerobic bottles is the difficulty in reading Gram-stained smears made from FAN bottles. The BACTEC resin particles are too large to pass through the lumen of needles (usually 20 to 22 gauge) used to remove samples from the bottles. The charcoal particles contained in the FAN medium, however, are relatively similar in size to bacterial and yeast cells and are unavoidably deposited onto slides when smears are prepared (13). We were unable to effect a practical method to separate the Ecosorb particles from the broth. In most instances the presence of the charcoal particles on the slide did not prevent accurate interpretation of the smears. However, there were occasions in which extra time was required to recognize the presence of gram-positive cocci or yeasts in proximity to aggregates of charcoal particles. In a few instances, organisms could not be found on smears from FAN bottles, but growth was present on the subculture plates on the following day.

In conclusion, this study has shown that the aerobic neutralization media presently available for use with the BACTEC and BacT/Alert blood culture instruments provide very similar rates of recovery of the most commonly encountered bacteria and fungi responsible for bloodstream infections in adults. Prior studies have demonstrated greater yields of some organisms with resin or FAN media than with the nonneutralization media also available for use with these two instruments (9, 13, 18). This study does not provide any insight into the recovery of obligately anaerobic or facultative bacteria with either an-

aerobic resin or FAN media. Thus, further studies are needed to determine whether there is any advantage to the use of both aerobic and anaerobic resin or FAN bottles for the detection of bacteremia in patients at risk of having anaerobic infection (10). The results of this study suggest that laboratories could consider convenience, ease of operation, software capabilities, medium choices, and cost as the principle distinguishing features between these two contemporary continuous monitoring blood culture systems with regard to the performance of aerobic blood cultures for adult patients.

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