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Multicenter Comparison of BACTEC 9050 and BACTEC 9240 Blood Culture Systems

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The overall recovery of organisms and time to detection with the BACTEC 9050 and BACTEC 9240 systems were compared in a multicenter evaluation. In the first phase of the study, a total of 4,383 compliant aerobic (Plus Aerobic/F) blood culture sets were processed. There was no significant difference in the recovery of individual groups of organisms with the two systems, with the exception of *Streptococcus pneumoniae* which was isolated more frequently with BACTEC 9050. False-positive signals occurred more often with BACTEC 9240 (58 cultures) than with BACTEC 9050 (43 cultures), but false-negative cultures were uncommon with both systems (3 cultures for each system). Time to detection of positive cultures of clinically significant organisms was essentially the same with both instruments. In the second phase of the study, 2,431 compliant anaerobic (Plus Anaerobic/F) blood culture sets were processed. There was no significant difference in the recovery of organisms with BACTEC 9050 compared with BACTEC 9240. Significantly ($P < 0.03$) more false-positive signals occurred with BACTEC 9240 (15 cultures) than with BACTEC 9050 (4 cultures). Likewise, more false-negative cultures occurred with BACTEC 9240 (11 cultures) than with BACTEC 9050 (8 cultures). Time to detection of positive cultures of clinically significant organisms was essentially the same with both systems with the exception of anaerobes ($N = 10$), which were recovered earlier ($P < 0.01$) with BACTEC 9240 (35.0 h) than with BACTEC 9050 (61.4 h).

The BACTEC 9000 series of blood culture systems (Becton Dickinson Microbiology Systems, Sparks, Md.) are fluorogenic, automated, noninvasive blood culture systems. Two models, BACTEC 9240 (240-bottle capacity) and BACTEC 9120 (120-bottle capacity), are essentially identical in design and differ only in their bottle capacity. Recently, a third model was introduced for use in small laboratories or clinics that process relatively few blood cultures. BACTEC 9050, with a capacity of 50 bottles, is a small, self-contained, automated system designed for processing three to five blood cultures per day. In addition to the difference in capacity, BACTEC 9050 differs from the larger systems by agitating the bottles continuously (versus intermittently for the other systems) and rotating the bottles to be read by one of three detectors (versus a dedicated detector for each stationary bottle in the large systems). The computer used to monitor the BACTEC 9050 bottles is contained within the system. Previous evaluations of the larger BACTEC 9000 instruments demonstrated excellent recovery and time of detection of positive blood cultures (1, 2, 4–7). In this evaluation, the performance properties of BACTEC 9050, using Plus Aerobic/F and Plus Anaerobic/F blood culture bottles, were compared with those of BACTEC 9240.

MATERIALS AND METHODS

Study participants. This study was performed in four clinical laboratories: Barnes-Jewish Hospital in St. Louis, Mo.; Rochester General Hospital in Rochester, N.Y.; DeKalb Medical Center, Decatur, Ga.; and Denver Health Medical Center, Denver, Colo.

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Study design. The performance of the BACTEC 9050 system was compared with that of the BACTEC 9240 system. In phase 1 of the study, the performance of Plus Aerobic/F medium was evaluated in the two systems. A total volume of 14 to 22 ml of blood was collected aseptically, divided equally into two Plus Aerobic/F bottles, and transported to the study laboratories. One bottle was placed into each instrument after it was determined that an equal volume of 7 to 11 ml of blood was inoculated into each bottle. Compliance was determined by measuring blood volumes when the bottles were received in the laboratories. All bottles were incubated for a minimum of 5 days according to the manufacturer's protocol. When a positive signal was obtained, the bottles were removed and an aliquot of the broth was Gram stained and processed for organism identification. Bottles with a false-positive signal were returned to the system for further incubation and testing. All negative bottles were subcultured blindly to chocolate agar plates and incubated aerobically at the end of the incubation period.

Phase 2 of the study was the evaluation of the Plus Anaerobic/F medium. A total volume of 14 to 22 ml of blood was collected aseptically, divided equally into Plus Anaerobic/F bottles, and transported to the study laboratories (Barnes-Jewish Hospital did not participate in this phase of the study). All subsequent processing was done as described above.

Data analysis. The modified chi-square test described by McNemar (3) was used to assess the statistical significance of differences observed between the two culture systems. When appropriate, the Yates correction for small numbers of observations was used.

RESULTS AND DISCUSSION

In the phase 1 aerobic comparison, 4,382 compliant blood culture sets were received and processed. A total of 585 (13.4%) positive cultures were detected with one or both BACTEC systems, a false-positive result (positive result with the BACTEC system but negative results for Gram stain and subculture) was recorded for 83 (1.9%) cultures, and 3,714 (84.7%) cultures had negative results. From the positive culture bottles, 651 organisms were isolated, including 366 judged to be clinically significant, 242 clinically insignificant, and 43 of unknown significance. Overall recovery of clinically significant organisms in the BACTEC 9050 and BACTEC 9240 systems is summarized in Table 1. The total numbers of organisms isolated with the BACTEC 9050 and BACTEC 9240 systems were 320 and 303, respectively. There was no significant difference

TABLE 1. Recovery of clinically significant organisms from BACTEC Plus Aerobic/F bottles

Organism (no.)	No. of organisms recovered by system		
	BACTEC 9050 only	BACTEC 9240 only	BACTEC 9050 and BACTEC 9240
Staphylococcus aureus (71)	9	4	58
Coagulase-negative staphylococci (43)	6	5	32
Streptococcus spp. (46)[a]	11	3	32
Enterococcus spp. (36)	10	6	20
Other gram-positive bacteria (6)[b]	1	2	3
Enterobacteriaceae (114)[c]	15	18	81
Pseudomonas spp. (16)	5	4	7
Other gram-negative bacteria (15)[d]	1	2	12
Mycobacterium fortuitum (1)	0	0	1
Candida spp. (16)	5	2	9
Cryptococcus spp. (2)	0	0	2

[a] Includes 29 *S. pneumoniae*, 15 viridans group streptococci, 1 group A, and 1 group B streptococcus.
[b] Includes three *Corynebacterium*, one *Aerococcus*, one *Actinomyces*, and one *Bacillus* organism.
[c] Includes 62 *Escherichia*, 18 *Klebsiella*, 22 *Enterobacter*, 7 *Proteus*, 3 *Serratia*, 1 *Morganella*, and 1 *Salmonella* organism.
[d] Includes five *Stenotrophomonas*, five *Acinetobacter*, two *Burkholderia*, two *Aeromonas*, and one *Alcaligenes* organism.

TABLE 2. Recovery of clinically significant organisms from the BACTEC Plus Anaerobic/F bottles

Organism (no.)	No. of organisms recovered by system		
	BACTEC 9050 only	BACTEC 9240 only	BACTEC 9050 and BACTEC 9240
Staphylococcus aureus (34)	1	2	31
Coagulase-negative staphylococci (26)	3	4	19
Streptococcus spp. (46)[a]	4	1	41
Enterococcus spp. (11)	4	1	6
Enterobacteriaceae (50)[b]	9	3	38
Other gram-negative bacteria (8)[c]	1	2	5
Clostridium spp. (8)	3	2	3
Bacteroides spp. (8)	5	2	1
Other anaerobes (6)[d]	1	3	2

[a] Includes 24 *S. pneumoniae*, 6 viridans group, 7 group A, 3 group B, 2 group C, 2 group D, and 2 group F streptococci.
[b] Includes 35 *Escherichia*, 7 *Klebsiella*, 5 *Proteus*, 2 *Morganella*, and 1 *Enterobacter* organism.
[c] Includes five *Haemophilus* organisms, one *Pseudomonas* organism, and two unidentified bacilli.
[d] Includes one *Peptostreptococcus* organism, one *Peptococcus* organism, and four unidentified bacilli.

in the recovery of individual groups of organisms in the two systems, with the exception of *Streptococcus pneumoniae*. Of the 29 cultures positive with *S. pneumoniae*, 8 were detected only with BACTEC 9050 and 1 was detected only with BACTEC 9240 ($P < 0.05$).

Equal numbers of clinically insignificant organisms were recovered with the two systems (144 isolates with each system), with the coagulase-negative staphylococci and *Corynebacterium* species the most common contaminants. A total of 43 organisms of unknown clinical significance was isolated in this phase of the study, with 30 and 26 recovered with the BACTEC 9050 and BACTEC 9240 systems, respectively.

False-positive results were observed in 83 cultures, including 17 cultures with both bottles positive, 40 cultures positive only with the BACTEC 9240 system, and 26 cultures positive only with the BACTEC 9050 system.

All negative blood culture bottles were blindly subcultured as described above. An additional six positive bottles, all with isolates of clinically significant organisms, were detected. Three BACTEC 9240 bottles were positive with *Candida glabrata* (the companion BACTEC 9050 bottles were negative), and three BACTEC 9050 bottles were positive for individual isolates of *C. glabrata*, *Corynebacterium jeikeium*, and *Streptococcus constellatus* (the companion BACTEC 9240 bottles were positive for *C. jeikeium* and *S. constellatus* but not for *C. glabrata*).

In the second phase of the study, 2,431 compliant blood culture sets were processed in the Plus Anaerobic/F medium. A total of 284 (11.7%) positive cultures were detected, a false-positive result was observed for 19 (0.8%) cultures (including 3 cultures with a true-positive companion bottle), and 2,131 (87.7%) cultures had negative results. From the positive culture bottles, 316 organisms were recovered, including 197 clinically significant isolates, 101 clinically insignificant isolates, and 18 organisms of unknown significance. The recovery of clinically significant organisms in the two systems is summarized in Table 2. There was no significant difference in the overall recovery of organisms with BACTEC 9050 (total recovery, 177 isolates) or BACTEC 9240 (170 isolates) or in the recovery of any individual group of organisms.

A total of 101 clinically insignificant organisms were recovered in this phase of the study, 60 with BACTEC 9050 and 61 with BACTEC 9240. In addition, the recovery of organisms with unknown clinical significance with the two systems was not significantly different (i.e., 14 with BACTEC 9050 and 10 with BACTEC 9240).

A total of 19 false-positive cultures were observed in the second phase of the study. There were 15 false-positive cultures with the BACTEC 9240 system and 4 with the BACTEC 9050 system ($P < 0.03$).

A total of 19 organisms were detected in 15 cultures by blind subculture. Eleven organisms including four clinically significant ones (two *Clostridium* spp., one *Pseudomonas aeruginosa*, and one unidentified anaerobic gram-negative bacillus) were present in BACTEC 9240 cultures and eight organisms including two clinically significant ones (one *P. aeruginosa* isolate and one *Staphylococcus aureus* isolate) were present in BACTEC 9050 cultures. Only two clinically significant isolates (one *S. aureus* and one *Clostridium* spp.) were detected by a positive signal in the companion bottle.

The time to detect positive cultures of clinically significant organisms is summarized in Tables 3 and 4. The time for detection using the Plus Aerobic/F bottles was essentially the same for the BACTEC 9050 system (mean detection time, 19.3 h) and the BACTEC 9240 system (19.1 h). All groups of organisms were detected rapidly, with the exception of the coagulase-negative staphylococci, *Corynebacterium* spp., yeasts, and *Mycobacterium fortuitum* (one isolate only). It is interesting to note that the time for detecting growth of yeasts was influenced by the species, with relatively rapid detection observed for *Candida albicans* (five isolates; mean detection time, 49.2 h with BACTEC 9050 and 44.0 h with BACTEC 9240) and *Candida tropicalis* (two isolates; 25.2 and 33.4 h) and slower detection of *C. glabrata* (two isolates; 134.1 and 149.6 h) and *Cryptococcus neoformans* (two isolates; 79.2 and 78.8 h).

The time for detection using the Plus Anaerobic/F bottles was similar for both systems (i.e., 17.8 h with the BACTEC 9050 system and 15.7 h with the BACTEC 9240 system). The

TABLE 3. Average time to detection with the BACTEC Plus Aerobic/F bottles

Organism (no.)	Avg detection time (h) with system	
	BACTEC 9050	BACTEC 9240
Staphylococcus aureus (58)	19.0	17.8
Coagulase-negative staphylococci (32)	25.0	22.9
Streptococcus spp. (32)	10.3	10.3
Enterococcus spp. (20)	15.5	15.1
Aerococcus species (1)	12.3	14.4
Corynebacterium spp. (2)	54.8	71.2
Enterobacteriaceae (81)	13.4	14.6
Pseudomonas spp. (7)	18.3	18.5
Other gram-negative bacteria (12)[a]	19.5	19.1
Mycobacterium fortuitum (1)	133.0	114.5
Candida spp. (9)	62.7	65.1
Cryptococcus spp. (2)	79.2	78.8

[a] Includes five *Stenotrophomonas*, three *Acinetobacter*, two *Burkholderia*, one *Alcaligenes*, and one *Aeromonas* organism.

observed difference in overall detection time was attributed to the slower recovery of five isolates of non-*Bacteroides* anaerobic bacteria ($P < 0.01$) with BACTEC 9050 (mean detection time, 81.7 h) than with BACTEC 9240 (mean, 30.5 h).

In summary, the overall recovery of organisms and time for detection of positive cultures with the BACTEC 9050 and 9240 blood culture systems were essentially the same. Minor differences between the two systems include better recovery of *S. pneumoniae*, fewer false-positive aerobic and anaerobic bottles, and fewer false-negative anaerobic bottles with the BACTEC 9050 system, and faster detection of anaerobic bacteria in anaerobic bottles incubated in the BACTEC 9240 system. During this evaluation, no technical failures were observed with the multiple BACTEC 9050 instruments used in the four study sites, and all study participants found the system to be easy to use. The BACTEC 9050 system is well suited for laboratories that process relatively few blood culture bottles and should offer significant advantages over the manual or older semiautomated blood culture systems that are used in these laboratories.

TABLE 4. Average time to detection with the BACTEC Plus Anaerobic/F bottles

Organism (no.)	Avg detection time (h) with system	
	BACTEC 9050	BACTEC 9240
Staphylococcus aureus (31)	17.8	16.5
Coagulase-negative staphylococci (19)	20.3	19.2
Streptococcus spp. (41)	10.4	10.5
Enterococcus spp. (6)	13.3	13.5
Enterobacteriaceae (38)	14.5	14.8
Other gram-negative bacteria (5)[a]	10.9	10.4
Anaerobes (10)[b]	61.4	35.0

[a] Includes three *Haemophilus* organisms and two unidentified bacilli.
[b] Includes five *Bacteroides* organisms, three *Clostridium* organisms, and two unidentified bacilli.

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