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Comparison of BacT/Alert with Signal Blood Culture System

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The BacT/Alert (Organon Teknika Corp., Durham, N.C.) is an automated blood culture system. It is based on the detection of CO_2 by means of a colorimetric sensor internally attached to the bottom of culture bottles. The aerobic and anaerobic media of this system were compared with one bottle of the Signal system (Oxoid Ltd., Hampshire, United Kingdom). At bedside, 20 ml of blood was drawn from each adult patient. The two BacT/Alert bottles were inoculated with 5 ml of blood each; the Signal bottle was inoculated with 10 ml. A total of 5,284 sets (2,483 patients; 2.1 cultures per patient) consisting of three bottles each were evaluated, of which 781 sets (14.8%) revealed microorganisms ($n = 892$); 642 of these were considered to be pathogenic. Significantly more ($P < 0.0001$) pathogens were isolated from the two BacT/Alert bottles together ($n = 584$) than from the single Signal bottle ($n = 515$). *Escherichia coli* ($P = 0.007$), gram-negative bacteria other than members of the family *Enterobacteriaceae* or *Pseudomonas* spp. ($P = 0.006$), and yeasts ($P = 0.02$) were isolated more often from both or either BacT/Alert bottle. Comparing the systems in terms of 388 different organisms per septic episode, the difference between BacT/Alert and Signal was significant for the total number of septicemia cases ($P = 0.003$). More contaminants grew in the BacT/Alert system (173 versus 116; $P = 0.0001$). False-positive indications were more frequent in the BacT/Alert system, 198 (3.7%) aerobic bottles and 57 (1.1%) anaerobic bottles, than in the Signal bottles, 24 (0.5%) bottles. Pathogens could be detected significantly earlier ($P < 0.0001$) in the BacT/Alert system than in the Signal system. The BacT/Alert instrument with two bottles allowed earlier detection as well as the isolation of more microorganisms than the manual, one-bottle Signal system.

During the last two decades, automated systems for the detection of microorganisms in blood cultures have been developed. Most automated systems are based on the detection of CO_2 by different technologies since the presence of microbial growth increases the CO_2 concentration in the culture media and in the gas phase of the bottles.

In 1990, Organon Teknika (Durham, N.C.) introduced an automated system for the detection of bloodstream pathogens, the BacT/Alert. It is based on the colorimetric detection of CO_2 concentrations by means of a sensor internally attached to the bottom of the blood culture bottles. Each sensor is monitored every 10 min by a reflectometer. Positive cultures are recognized by a computer-driven algorithm that monitors initial CO_2 and increased CO_2 concentrations. The BacT/Alert system is capable of incubating, agitating, and continuously monitoring aerobic and anaerobic culture bottles (12, 15). The inoculation of 5 to 10 ml of blood into each bottle is recommended for the optimal yield of bloodstream pathogens.

Another blood culture system which detects microbial metabolism, the Signal system of Oxoid (Basingstoke, United Kingdom), has been previously described (10). Positive pressure created by microbial metabolism in a sealed bottle displaces blood broth into a connected upper chamber, the Signal device. The manufacturer warrants that potential aerobic and anaerobic microorganisms causing septicemia can be isolated from one Signal bottle inoculated with 10 ml of blood. This manual system requires regular inspection of the vials at least once daily.

As these two systems indirectly indicate positive blood cultures, we decided to compare their performances in recovering pathogens and the speed with which they do so. Special attention was given to the analysis of possible causes of unconfirmed positive cultures. In order to compare equal blood volumes cultured in the two systems, the BacT/Alert aerobic and anaerobic bottles were inoculated with 5 ml each and the Signal bottle was inoculated with 10 ml. A better yield of a larger range of microorganisms could be expected from the two-bottle BacT/Alert system because the culture media can be adequately supplemented to ensure the growth of either aerobic or anaerobic microorganisms. A one-bottle system such as the Signal system favors one or another organism group or finds a compromise.

(These results were presented in part at the 92nd General Meeting of the American Society for Microbiology in New Orleans, La., 1992 [1].)

MATERIALS AND METHODS

Ward personnel were asked to draw about 20 ml of blood by syringe and needle from each adult patient with suspected septicemia seeking medical care at the emergency ward of the University Hospital Geneva (1,500 beds). Per septic episode, it was recommended that three blood cultures be drawn within 24 h within an interval of at least 30 min (6). The blood was immediately distributed as follows: 5 ml in the BacT/Alert aerobic bottle, 5 ml in the BacT/Alert anaerobic bottle, and 10 ml in the Signal bottle.

The BacT/Alert bottles contain 40 ml of tryptic soy broth and 0.035% sodium polyanetholesulfonate with different supplements for the aerobic or anaerobic medium. The Signal bottles contain 70 ml of supplemented tryptic soy broth and 0.03% sodium polyanetholesulfonate.

In the laboratory, all inoculated bottles were compared with standards of known volumes. BacT/Alert bottles containing less than 4 ml or more than 6 ml of blood and Signal bottles containing less than 8 ml or more than 12 ml were considered to be inappropriately filled for study purposes and were excluded from the evaluation. The BacT/Alert aerobic bottles were vented with a needle; thereafter, they were registered and introduced into the BacT/Alert system with the BacT/Alert anaerobic bottles. Under continuous rocking at 68 cycles per min, these bottles were incubated for 7 days at 35°C. Positive cultures were indicated by a signal on the computer screen accompanied by a beeping sound. Up to three times daily, positive vials were removed from the BacT/Alert instrument for further workup.

The Signal device was inserted onto the Signal bottles, and the bottles were then incubated at 35°C for 7 days, under continuous agitation for the first 24 h. Twice daily, these bottles were inspected for microbial growth during the first 2

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days of incubation; thereafter, they were inspected once a day. Microbial growth was indicated by blood broth in the Signal recipient or by broth turbidity.

During the working hours of the laboratory from 7 a.m. to 7 p.m., broth media of vials indicated as positive were Gram stained, subcultured onto 5% sheep blood agar–chocolate agar, and incubated aerobically with 5% CO_2 at 35°C; one plate containing CDC anaerobe blood agar was incubated for at least 1 week anaerobically. Culture bottles considered negative by the above-mentioned criteria were subcultured only when another bottle of the set revealed an organism. With the aid of an infectious disease specialist, microorganisms were classified as clinically important or contaminants on the basis of clinical and previously published criteria (14).

The amount of blood cultured is critical for the yield of microorganisms (3, 4). Therefore, the combined culture results obtained with the BacT/Alert aerobic and anaerobic bottles were compared with the results achieved with the single Signal bottle, since the BacT/Alert bottles were inoculated with 5 ml of blood and the Signal bottles were inoculated with 10 ml. When an identical organism could be identified from several blood cultures that had been drawn within 48 h, these organisms were considered the cause of one septic episode. Furthermore, the yields of all organisms apart from septic episodes were compared. The time intervals between venipuncture and the detection of a positive culture during working hours were compared individually for the BacT/Alert aerobic versus the Signal bottles and the BacT/Alert anaerobic versus the Signal bottles. The McNemar Exact Test was applied for statistical evaluation of the comparisons.

RESULTS

A total of 5,566 blood culture sets consisting of three bottles each were received, of which 5,284 sets were evaluable. Blood was drawn from 2,483 patients, resulting in 2.1 cultures per patient. Of these cultures, 781 (14.8%) revealed at least one organism from 528 patients (21%), while 202 (4%) cultures were considered to be contaminated. Only 11.1% ($n = 584$) of the 5,284 sets were inoculated with blood from patients receiving antimicrobial agents shortly before the blood was drawn. The positivity rate for patients older than 60 years was >15%, whereas it was ≤14% for patients younger than 60 years.

Of the 892 organisms identified, 642 were considered clinically relevant in 388 septic episodes. The septic episodes were revealed more often ($P = 0.003$) by the BacT/Alert system alone ($n = 70$) than by the Signal system alone ($n = 38$), as illustrated in Table 1. Septic episodes of *Streptococcus pneumoniae* and yeasts tended to be detected more often in the BacT/Alert system, without reaching statistical significance. Overall, the presence of 584 pathogens was indicated by the BacT/Alert system versus 515 pathogens detected by the Signal system ($P < 0.0001$). More yeasts ($P = 0.02$), *Escherichia coli* organisms ($P = 0.007$), and gram-negative bacteria other than members of the *Enterobacteriaceae* family or *Pseudomonas* spp. ($P = 0.006$) were identified with the BacT/Alert bottles (Table 2). Of 29 septic episodes with anaerobic bacteria (7 were mixed with 2 anaerobes and 1 was mixed with 3 anaerobes), 21 were detected with the Signal system and 22 were detected with the BacT/Alert system. Regarding the BacT/Alert system alone for these 22 septicemia episodes, 4 anaerobes were isolated from the aerobic vial only, while 11 were detected with the anaerobic vial only. For 5 of these 11 anaerobes, the laboratory received the clinical information that the patients presented with abdominal signs and symptoms.

The BacT/Alert cultures (two bottles) were more often contaminated ($P = 0.0001$). From 198 (3.7%) BacT/Alert aerobic bottles and 57 (1.1%) BacT/Alert anaerobic bottles which the instrument declared positive, no microorganisms could be cultured. Signal bottles were falsely positive in 24 (0.5%) instances.

The BacT/Alert instrument did not detect three pathogenic organisms (two *Pseudomonas aeruginosa* and one *Brucella melitensis* isolate) present in the aerobic culture media; one of these was detected in the BacT/Alert anaerobic companion vial of the same set. Furthermore, the instrument did not detect seven microorganisms (two *P. aeruginosa*, two *Xanthomonas maltophilia*, one *Actinomyces meyeri*, one *B. melitensis*, and one *Candida albicans* isolate) present in the anaerobic media; four of these were detected in the BacT/Alert aerobic companion bottle. The Signal system could not detect eight pathogens present in the medium (two *C. albicans*, two *Cryptococcus neoformans*, one *Bacteroides fragilis*, one *B. melitensis*, one *Campylobacter jejuni*, and one *Haemophilus influenzae* isolate).

The clinically important organisms were detected in the BacT/Alert aerobic bottle, on average, at 27 h (±24 h) after inoculation; in the BacT/Alert anaerobic bottle, at 28 h (±22 h); and in the Signal system, at 39 h (±34 h). The median detection times were 20 h for the two BacT/Alert bottles and 27 h for the Signal system. Within 24 h after inoculation, 68, 68,

TABLE 1. Comparison of clinically relevant microorganisms isolated from the BacT/Alert and/or Oxoid Signal blood culture system per septic episode

Organisms	No. isolated			*P* value[a]
	BacT/Alert and Signal	BacT/Alert only	Signal only	
Staphylococcus aureus	42	6	3	0.5 (NS)
Coagulase-negative staphylococci[b]	9	0	0	
Streptococcus pneumoniae	48	8	3	0.23 (NS)
Streptococcus sp. group A, B, or G[c]	13	4	1	0.38 (NS)
Enterococcus spp.[d]	6	1	4	0.38 (NS)
Other *Streptococcus* spp.[e]	15	0	3	0.25 (NS)
Escherichia coli	82	16	9	0.23 (NS)
Other *Enterobacteriaceae*[f]	32	8	4	0.39 (NS)
Pseudomonas spp.[g]	9	3	1	0.63 (NS)
Other gram-negative bacteria[h]	4	7	1	0.07 (NS)
Gram-positive anaerobes[i]	7	6	4	0.75 (NS)
Gram-negative anaerobes[j]	12	5	4	1 (NS)
Yeasts[k]	1	6	1	0.13 (NS)
Total	280	70	38	0.003

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

[b] One *Staphylococcus capitis*, seven *Staphylococcus epidermidis*, and one *Staphylococcus warneri* isolate.

[c] Eight *Streptococcus* sp. group A, seven *Streptococcus* sp. group B, and three *Streptococcus* sp. group G isolates.

[d] One *Enterococcus avium*, eight *Enterococcus faecalis*, and two *Enterococcus faecium* isolates.

[e] One *Aerococcus viridans*, one *Gemella haemolysans*, three *Streptococcus bovis*, five *Streptococcus anginosus*, one *Streptococcus mitis*, three *Streptococcus salivarius*, and four *Streptococcus sanguis* isolates.

[f] One *Citrobacter amalonaticus*, 1 *Enterobacter aerogenes*, 4 *Enterobacter cloacae*, 4 *Klebsiella oxytoca*, 16 *Klebsiella pneumoniae*, 2 *Morganella morganii*, 3 *Proteus mirabilis*, 2 *Proteus vulgaris*, 4 *Salmonella enteritidis*, 1 *Salmonella* sp. group C, 1 *Salmonella paratyphi* A, 4 *Salmonella typhi*, and 1 *Salmonella typhimurium* isolate.

[g] Ten *Pseudomonas aeruginosa*, two *Pseudomonas alcaligenes*, and one *Xanthomonas maltophilia* isolate.

[h] One *Acinetobacter baumannii*, one *Actinobacillus actinomycetemcomitans*, two *Campylobacter jejuni*, five *Haemophilus influenzae*, one *Haemophilus parainfluenzae*, and two *Neisseria meningitidis* isolates.

[i] Three *Actinomyces meyeri*, one *Bifidobacterium* sp., five *Clostridium perfringens*, one *Clostridium ramosum*, one *Eubacterium lentum*, one *Peptostreptococcus asaccharolyticus*, three *Peptostreptococcus micros*, and two *Peptostreptococcus* sp. isolates.

[j] Five *Bacteroides thetaiotaomicron*, one *Bacteroides denticola*, one *Bacteroides distasonis*, eight *Bacteroides fragilis*, one *Bacteroides ovatus*, one *Fusobacterium mortiferum*, three *Fusobacterium necrophorum*, and one *Fusobacterium nucleatum* isolate.

[k] Three *Candida albicans*, one *Candida pseudotropicalis*, three *Cryptococcus neoformans*, and one *Torulopsis glabrata* isolate.

TABLE 2. Comparison of all microorganisms isolated from the BacT/Alert and/or the Oxoid Signal blood culture system

Organisms	No. isolated			*P* value[a]
	BacT/Alert and Signal	BacT/Alert only	Signal only	
Staphylococcus aureus	76	11	5	0.2 (NS)
Coagulase-negative staphylococci[b]	18	2	1	1 (NS)
Streptococcus pneumoniae	78	15	6	0.08 (NS)
Streptococcus sp. group A, B, or G[c]	20	10	3	0.09 (NS)
Enterococcus spp.[d]	14	2	5	0.45 (NS)
Other *Streptococcus* spp.[e]	30	1	4	0.38 (NS)
Escherichia coli	126	32	13	0.007
Other *Enterobacteriaceae*[f]	47	16	8	0.15 (NS)
Pseudomonas spp.[g]	14	6	1	0.13 (NS)
Other gram-negative bacteria[h]	5	11	1	0.006
Gram-positive anaerobes[i]	10	6	5	1 (NS)
Gram-negative anaerobes[j]	16	6	5	1 (NS)
Yeasts[k]	3	9	1	0.02
Total	457	127	58	<0.0001
Contaminated (no.)	39	134	77	0.0001

[a] NS, not significant ($P > 0.05$).
[b] Two *Staphylococcus capitis*, 17 *Staphylococcus epidermidis*, and 2 *Staphylococcus warneri* isolates.
[c] Twelve *Streptococcus* sp. group A, 15 *Streptococcus* sp. group B, and 6 *Streptococcus* sp. group G isolates.
[d] One *Enterococcus avium*, 17 *Enterococcus faecalis*, and 3 *Enterococcus faecium* isolates.
[e] Two *Aerococcus viridans*, one *Gemella haemolysans*, eight *Streptococcus bovis*, seven *Streptococcus anginosus*, two *Streptococcus mitis*, six *Streptococcus salivarius*, and seven *Streptococcus sanguis* isolates.
[f] Two *Citrobacter amalonaticus*, 1 *Enterobacter aerogenes*, 9 *Enterobacter cloacae*, 5 *Klebsiella oxytoca*, 29 *Klebsiella pneumoniae*, 3 *Morganella morganii*, 4 *Proteus mirabilis*, 3 *Proteus vulgaris*, 6 *Salmonella enteritidis*, 1 *Salmonella* sp. group C, 2 *Salmonella paratyphi* A, 5 *Salmonella typhi*, and 1 *Salmonella typhimurium* isolate.
[g] Sixteen *Pseudomonas aeruginosa*, three *Pseudomonas alcaligenes*, and two *Xanthomonas maltophilia* isolates.
[h] Two *Acinetobacter baumannii*, two *Actinobacillus actinomycetemcomitans*, three *Campylobacter jejuni*, six *Haemophilus influenzae*, one *Haemophilus parainfluenzae*, and three *Neisseria meningitidis* isolates.
[i] Four *Actinomyces meyeri*, one *Bifidobacterium* sp., five *Clostridium perfringens*, one *Clostridium ramosum*, one *Eubacterium lentum*, one *Peptostreptococcus asaccharolyticus*, five *Peptostreptococcus micros*, and three *Peptostreptococcus* sp. isolates.
[j] Five *Bacteroides thetaiotaomicron*, 2 *Bacteroides denticola*, 1 *Bacteroides distasonis*, 12 *Bacteroides fragilis*, 1 *Bacteroides ovatus*, 2 *Fusobacterium mortiferum*, 3 *Fusobacterium necrophorum*, and 1 *Fusobacterium nucleatum* isolate.
[k] Seven *Candida albicans*, two *Candida pseudotropicalis*, three *Cryptococcus neoformans*, and one *Torulopsis glabrata* isolate.

and 45% of the respective cultures were positive (Fig. 1). Of the 429 organisms detected in the BacT/Alert aerobic bottle and the Signal bottle, 145 were detected >12 h earlier in the BacT/Alert system and only 18 were detected >12 h earlier in the Signal system ($P < 0.0001$). *Staphylococcus aureus* ($P < 0.0001$), *S. pneumoniae* ($P = 0.004$), other *Streptococcus* spp. ($P = 0.002$), *E. coli* ($P = 0.0003$), other *Enterobacteriaceae* members ($P < 0.0001$), and *Pseudomonas* spp. ($P = 0.002$) were detected earlier by the BacT/Alert aerobic bottle (Table 3). Similarly, these species were also detected earlier with the BacT/Alert anaerobic bottle than with the Signal bottle, with the exception of *S. pneumoniae* and *Pseudomonas* spp. (Table 4).

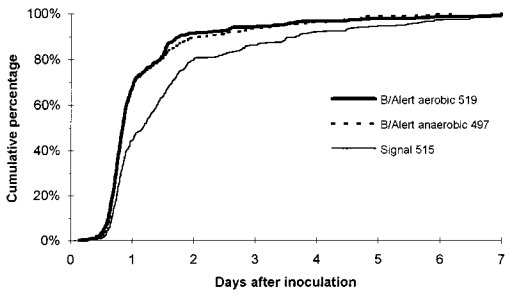

FIG. 1. Cumulative detection time for 519 BacT/Alert aerobic, 497 BacT/Alert anaerobic, and 515 Signal blood cultures revealing clinically relevant organisms.

DISCUSSION

This evaluation compared the performance of the automated, two-bottle BacT/Alert system with that of the manual, single-bottle Signal system. The patients with suspected septicemia included in the study were adults presenting to the emergency ward. This explains the high positivity rate of blood cultures in this study (14.8%), as well as the observation that only 11.1% of the patients received antimicrobial agents prior to venipuncture for blood culture (8). This setting was chosen since neither the BacT/Alert media nor the Signal medium contained special antimicrobial neutralizing agents. Of all of our hospitalized patients, 50% are under antimicrobial therapy when blood is drawn for cultures (8). Most blood cultures were requested for patients older than 60 years, and this group also had the highest rate of septicemia. This observation is consistent with reports elsewhere (2, 7).

The two BacT/Alert bottles were evaluated versus one Sig-

TABLE 3. Comparison of detection times for 429 clinically important microorganisms isolated in both BacT/Alert aerobic and Oxoid Signal blood culture systems

Organisms	No. isolated by:			*P* value[a]
	BacT/Alert aerobic and Signal at same time	BacT/Alert aerobic >12 h earlier	Signal >12 h earlier	
Staphylococcus aureus	35	39	2	<0.0001
Coagulase-negative staphylococci	11	5	1	0.22 (NS)
Streptococcus pneumoniae	66	9	0	0.004
Streptococcus sp. group A, B, or G	17	3	0	0.25 (NS)
Enterococcus spp.	9	5	0	0.06 (NS)
Other *Streptococcus* spp.	16	13	1	0.002
Escherichia coli	74	35	10	0.0003
Other *Enterobacteriaceae*	30	15	0	<0.0001
Pseudomonas spp.	3	10	0	0.002
Other gram-negative bacteria	0	4	1	0.38 (NS)
Gram-positive anaerobes	0	3	0	0.25 (NS)
Gram-negative anaerobes	3	3	3	1 (NS)
Yeasts	2	1	0	1 (NS)
Total	266	145	18	<0.0001

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

TABLE 4. Comparison of detection times for 423 clinically important microorganisms isolated in both BacT/Alert anaerobic and Oxoid Signal blood culture systems

Organisms	No. isolated by:			*P* value[a]
	BacT/Alert anaerobic and Signal at same time	BacT/Alert anaerobic >12 h earlier	Signal >12 h earlier	
Staphylococcus aureus	38	34	2	<0.0001
Coagulase-negative staphylococci	11	4	1	0.38 (NS)
Streptococcus pneumoniae	64	6	2	0.29 (NS)
Streptococcus sp. group A, B, or G	18	2	0	0.5 (NS)
Enterococcus spp.	10	4	0	0.13 (NS)
Other *Streptococcus* spp.	17	11	1	0.006
Escherichia coli	80	29	10	0.003
Other *Enterobacteriaceae*	35	10	1	0.012
Pseudomonas spp.	0	4	0	0.13 (NS)
Other gram-negative bacteria	0	4	0	0.13 (NS)
Gram-positive anaerobes	1	2	5	0.45 (NS)
Gram-negative anaerobes	6	6	2	0.29 (NS)
Yeasts	2	1	0	1 (NS)
Total	282	117	24	<0.0001

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

nal bottle so that equal volumes of blood (10 ml) sampled for culture could be compared (3, 4). Furthermore, the manufacturer of the Signal system claims that the medium allows growth of aerobic and anaerobic microorganisms, whereas the BacT/Alert producer recommends two separate bottles for the optimal isolation of aerobes and anaerobes. In the present evaluation, microorganisms grew more often in either or both BacT/Alert bottles than in the Signal bottle ($P < 0.0001$). Aerobic bacteria tended to grow better in the BacT/Alert system. The advantage of using two culture media with different supplements for the BacT/Alert system over the single medium of the Signal system is revealed by the better recovery of yeasts in the BacT/Alert aerobic medium versus the Signal bottle. Since both the BacT/Alert aerobic and the Signal vials were vented in the laboratory, the atmosphere in the gas phase of these vials was similar and would not influence the yield of aerobic microorganisms. The BacT/Alert aerobic bottle yielded as many pathogenic organisms ($n = 519$) from 5 ml of blood as the Signal vial yielded from 10 ml ($n = 515$). Recently, Weinstein et al. reported that 10 ml of blood inoculated into aerobic BacT/Alert bottles yielded 7.2% more positive cultures than companion BacT/Alert aerobic bottles inoculated with 5 ml (13). It would be interesting to know whether two identical vials inoculated with 5 ml of blood perform better than a single vial with 10 ml of blood.

The decline of blood cultures yielding anaerobic bacteria in recent series has questioned the routine use of anaerobic media (5). In our study the percentage of anaerobes among the isolated microorganisms was relatively high, 7.4%. By the BacT/Alert system only, the anaerobic culture vials alone yielded 11 septicemic episodes with anaerobes. Of the 11 patients, at least 5 presented with abdominal signs and symptoms. On the basis of these results, we are in favor of culturing selectively for anaerobes and of routinely using two aerobic vials, as suggested elsewhere (5).

The chance of contaminating two bottles is higher, as revealed in this study by the two BacT/Alert bottles which were more often contaminated ($P = 0.0001$) than the single Signal vial (Table 2). Moreover, a single BacT/Alert vial (aerobic or anaerobic) costs about as much as the Signal vial in our country.

A direct comparison of the BacT/Alert aerobic medium with another manual blood culture system, the Septi-Chek system (Becton Dickinson, Sparks, Md.), would be of interest because of the much better performance of the Septi-Chek Release medium compared with the Signal medium (9).

The BacT/Alert system indicated significantly more unconfirmed positive vials (aerobic, 3.7%; anaerobic, 1.1%) than the Signal vials (0.5%), with the classical subculture as the endpoint. Microorganisms not detectable by the classical Gram stain or aerobic and anaerobic subcultures such as *Mycoplasma* spp., *Leptospira* spp., *Borrelia* spp., *Mycobacterium* spp., *Rickettsia* spp., or *Chlamydia* spp. may have been present in these unconfirmed positive vials. Overfilled vials excluded from the study were noted frequently to be unconfirmed positives (66 BacT/Alert aerobic, 15 BacT/Alert anaerobic, and 1 Signal).

On the basis of previous reports of the BacT/Alert system, systematic terminal subcultures were thought not to be necessary and therefore were not performed (15). However, terminal subcultures of bottles declared negative by the different systems were performed after a 7-day incubation period when another bottle of the blood culture set was positive. Surprisingly, two *P. aeruginosa* strains present in the vented BacT/Alert aerobic medium were not declared positive by the instrument. They may not have produced enough CO_2 to reach the threshold necessary for positivity. In contrast to other reports, the BacT/Alert bottles were unable to reveal a *B. melitensis* isolate present in the culture media during this study within 7 days of incubation (11). This observation may need further investigation in regions with epidemic brucellosis. Since our patient showed no clear clinical symptoms of brucellosis, the incubation period of the vials had not been prolonged as recommended (6). However, that other aerobic microorganisms such as *X. maltophilia*, *Cryptococcus neoformans*, and *Candida albicans* may not be well detected with an anaerobic medium or the Signal system has been previously reported (9, 15).

The automated BacT/Alert system allowed a significantly ($P < 0.0001$) earlier detection of most aerobic bloodstream pathogens than the manual Signal system, even though laboratory technologists were only present 12 h daily and positive cultures were processed, at most, three times daily. A 10-ml blood volume in a BacT/Alert vial would have shortened the time to positivity (14). The colorimetric detection of CO_2 produced by microorganisms with the BacT/Alert system is certainly more sensitive than the gas capture system of the Signal system. Furthermore, the frequent monitoring of all culture bottles every 10 min in the automated BacT/Alert system also shortened the detection time. The clinical impact of rapid in vitro identification and susceptibility testing of pathogenic microorganisms has been established (1a). More than 12 working h daily or more frequent processing of positive blood cultures may slightly accelerate the availability of the results, but this procedure would be less cost-effective.

The handling time for the two systems is similar. The time needed to vent the aerobic BacT/Alert vials corresponds to the time required to insert the Signal device onto the Signal bottles. The invested labor for the daily inspection of the Signal bottles represents about the same time needed for clerical

work with the BacT/Alert system. Manual systems do not need the acquisition of an expensive instrument and have the other advantage of not being dependent on this instrument. During this study, two technical failures of the BacT/Alert system caused considerable concern.

This study demonstrated that the BacT/Alert system using two vials detected significantly more microorganisms than the manual Signal system and did so more rapidly. The impact of early detection of positive blood cultures on patient care and costs should be assessed. Furthermore, studies are needed to ascertain the possible reduction of workload with the BacT/Alert system. These studies will help to determine whether the acquisition of an instrument such as the BacT/Alert is justified.

REFERENCES

1. **Auckenthaler, R., B. Pepey, and P. Rohner.** 1992. Comparison of the BacT/Alert with the Signal Oxoid blood culture system, abstr. C-55, p. 429. *In* Abstracts of the 92nd General Meeting of the American Society for Microbiology 1992. American Society for Microbiology, Washington, D.C.

1a. **Doern, G. V., R. Vautour, M. Gaudet, and B. Levy.** 1994. Clinical impact of rapid in vitro susceptibility testing and bacterial identification. J. Clin. Microbiol. **32:**1757–1762.

2. **Eykyn, J. S., E. R. Gransden, and I. Phillips.** 1990. The causative organisms of septicemia and their epidemiology. J. Antimicrob. Chemother. **25**(Suppl. C)**:**41–58.

3. **Illstrup, D. M., and J. A. Washington II.** 1983. The importance of volume of blood cultured in the detection of bacteremia and fungemia. Diagn. Microbiol. Infect. Dis. **1:**107–110.

4. **Mermel, L. A., and D. G. Maki.** 1993. Detection of bacteremia in adults: consequences of culturing an inadequate volume of blood. Ann. Intern. Med. **119:**270–272.

5. **Morris, A. J., M. L. Wilson, S. Mirrett, and L. B. Reller.** 1993. Rationale for selective use of anaerobic blood cultures. J. Clin. Microbiol. **31:**2110–2113.

6. **Reller, L. B., P. R. Murray, and J. D. MacLowry.** 1982. Cumitech 1A, Blood cultures II. Coordinating ed., J. A. Washington II. American Society for Microbiology, Washington, D.C.

7. **Roberts, F. J., I. W. Geere, and A. Coldman.** 1991. A three-year study of positive blood cultures, with emphasis on prognosis. Rev. Infect. Dis. **13:**34–46.

8. **Rohner, P., and R. Auckenthaler.** 1993. Blood culture results of ambulatory versus hospitalized patients, abstr. C-231, p. 487. *In* Abstracts of the 93rd General Meeting of the American Society for Microbiology 1993. American Society for Microbiology, Washington, D.C.

9. **Rohner, P., H. Burkardt, H. Dreismann, and R. Auckenthaler.** 1991. Evaluation of the new improved BCB Release blood culture medium for the BCB Roche system. Eur. J. Clin. Microbiol. Infect. Dis. **10:**620–624.

10. **Sawhney, D., S. Hinder, D. Swaine, and E. Y. Bridson.** 1986. Novel method for detecting microorganisms in blood cultures. J. Clin. Pathol. **39:**1259–1263.

11. **Solomon, H. M., and D. Jackson.** 1992. Rapid diagnosis of *Brucella melitensis* in blood: some operational characteristics of the BACT/ALERT. J. Clin. Microbiol. **30:**222–224.

12. **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. **28:**1608–1612.

13. **Weinstein, M. P., S. Mirrett, M. L. Wilson, L. G. Reimer, and L. B. Reller.** 1994. Controlled evaluation of 5 versus 10 milliliters of blood cultured in aerobic BacT/Alert blood culture bottles. J. Clin. Microbiol. **32:**2103–2106.

14. **Weinstein, M. P., L. B. Reller, J. R. Murphy, and K. A. Lichtenstein.** 1983. The clinical significance of positive blood cultures: a comprehensive analysis of 500 episodes of bacteremia and fungemia in adults. I. Laboratory and epidemiologic observations. Rev. Infect. Dis. **5:**35–53.

15. **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.