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Clinical Comparison of Difco ESP, Wampole Isolator, and Becton Dickinson Septi-Chek Aerobic Blood Culturing Systems

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The ESP 80A aerobic blood culture of the ESP automated blood culture system (Difco Laboratories, Detroit, Mich.) was compared with two manual aerobic blood culture systems, the Isolator (Wampole Laboratories, Cranbury, N.J.) and the Septi-Chek (Becton Dickinson, Cockeysville, Md.) systems, for the detection of bloodstream microorganisms from 5,845 blood samples for culture collected from adult patients with suspected septicemia. The bottles were incubated for 7 days, and the sediment from the Isolator tube was inoculated onto solid medium and this medium was incubated for 72 h. A total of 609 microorganisms were recovered from 546 blood cultures. There was no statistically significant difference in the total recovery of microorganisms for the ESP 80A system when compared with that for the Septi-Chek system ($P = 0.083$); however, the Isolator system recovered significantly more microorganisms overall than either the ESP 80A ($P < 0.001$) or the Septi-Chek ($P < 0.001$) system. When assessing individual probable pathogens, the Isolator system detected statistically significantly more *Staphylococcus aureus* and *Candida* spp. than either the ESP 80A or the Septi-Chek system ($P < 0.05$). Similarly, the Isolator system detected statistically significantly more bloodstream infections (septic episodes) caused by *S. aureus* and *Candida* spp. than either the ESP 80A or the Septi-Chek system ($P < 0.05$). In blood culture sets which produced growth of the same probable pathogens in the ESP 80A and the Isolator systems, there was no statistically significant difference in the median times to detection for all pathogens combined ($P = 0.067$). However, a similar comparison showed the Isolator and the ESP 80A systems to have statistically significantly shorter median detection times for all pathogens combined ($P < 0.001$) when they were independently compared with the Septi-Chek system. The ESP 80A system had 29 (0.5%) false-positive signals. The ESP system required less processing time than the Isolator system and eliminates the hands-on time for the detection of positive cultures required by the manual systems.

Two manual aerobic blood culture systems used routinely at Mayo Clinic Rochester, the Isolator (Wampole Laboratories, Cranbury, N.J.) and the Septi-Chek (Becton Dickinson, Cockeysville, Md.) systems, were compared with the aerobic ESP 80A blood culture of the ESP automated blood culture system (Difco Laboratories, Detroit, Mich.) for the recovery of microorganisms from the blood of adult patients. The ESP system detects pressure changes in blood culture bottles as the result of CO_2 production or O_2 consumption by growing microorganisms (7). The detection frequencies and times for the detection of bloodstream microorganisms and the detection frequencies of bloodstream infections (septic episodes) by the three aerobic components were compared.

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MATERIALS AND METHODS

Phlebotomists aseptically collected approximately 30 ml of peripheral blood from each patient (age, ≥16 years) using a needle and a syringe. Equal volumes of this blood sample were inoculated into blood culture receptacles at the patient's bedside by using an inoculation sequence predetermined for each set of blood culture bottles by a randomization schedule. Therefore, blood was distributed equally into an aerobic ESP 80A bottle, a 10-ml Isolator tube, a Septi-Chek bottle, and a 100-ml nonvented Trypticase soy bottle (Becton Dickinson). Because of limitations on the amount of blood collected per phlebotomy, the evaluation did not permit a comparison of the ESP 80N system, the anaerobic bottle of the ESP system, with our routine manual anaerobic blood culture bottle, the nonvented bottle containing Trypticase soy broth. A total collection volume of at least 26 ml (6.5 ml per receptacle) was required for inclusion in the study.

The Isolator tube was processed according to the manufacturer's instructions. The Isolator sediment was inoculated onto 5% sheep blood Trypticase soy agar (SBA) and chocolate agar (CBA), which were incubated at 35°C with 5 to 10% CO_2 for 72 h, and brain heart infusion agar (BHI), inhibitory mold agar (IMA), and Sabouraud dextrose agar (SAB), which were incubated at 30°C for 7 days. Upon receipt in the microbiology laboratory, the Septi-Chek agar slide was attached to the bottle. The nonvented Trypticase soy broth and Septi-Chek slide were incubated for 7 days at 35°C. The SBA and CBA Isolator sediment plates, nonvented Trypticase soy broth, and Septi-Chek slide were manually examined twice daily during the first 48 h after collection and daily thereafter. After examination, the Septi-Chek slide was reinoculated by inverting the Septi-Chek bottle. BHI, IMA, and SAB plates were examined once daily.

Upon receipt in the laboratory, an ESP connector was placed onto the ESP 80A bottle. This removes any residual pressure in the bottle and links the bottle's headspace with the instrument's sensor. The bottles were loaded into the instrument into the computer-assigned position. ESP 80A bottles were continuously agitated. The ESP unit was observed at 4-h intervals for positive signals. Whenever a positive signal occurred, the bottle was removed from the instrument for Gram staining and subculture. If the Gram stain was negative, the bottle was allowed to equilibrate to room temperature for 1 h before the bottle was returned to the instrument. Bottles that produced positive signals but that were negative on Gram staining and subculture to CBA incubated at 35°C with 5 to

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TABLE 1. Comparison of the ESP 80A system with the Isolator system

Microorganism	No. of isolates detected by:				*P* value[b]
	Isolator only	ESP 80A only	Both systems	Neither system[a]	
All microorganisms	222	84	214	89	<0.001
Probable pathogens					
All microorganisms	107	61	211	55	<0.001
Staphylococcus aureus	32	6	57	5	<0.001
Staphylococcus spp., coagulase negative	2	14	35	0	0.004
Streptococcus pneumoniae	0	3	1	0	NS[c]
Streptococcus spp., viridans group	0	0	9	3	NS
Enterococcus spp.	8	4	11	3	NS
Escherichia coli	9	7	19	6	NS
Other members of the family *Enterobacteriaceae*	18	11	28	11	NS
Pseudomonas spp.	9	4	11	1	NS
Obligately anaerobic bacteria	0	5	0	17	NS (0.063)
Candida spp.	26	5	35	6	<0.001
Other fungi	1	0	0	0	NS
Other bacteria	2	2	5	3	NS
Probable contaminants					
All organisms	115	23	3	34	<0.001
Bacillus sp.	5	0	0	0	NS (0.063)
Corynebacterium spp.[d]	7	3	0	2	NS
Propionibacterium spp.	0	3	0	5	NS
Lactobacillus sp.	1	0	0	0	NS
Other	9	1	3	3	0.022
Staphylococcus spp., coagulase negative	91	11	0	23	<0.001
Streptococcus spp., viridans group	2	5	0	1	NS

[a] Neither refers to the numbers of isolates detected only by the Septi-Chek blood culture system.
[b] Refer to Materials and Methods for the method of calculation of *P* values.
[c] NS, not significant ($P > 0.05$).
[d] Does not include *Corynebacterium jeikeium.*

10% CO_2 and SBA under anaerobic conditions were recorded as instrument false positives.

Microorganisms isolated from positive cultures were identified by standard biochemical techniques. Time to detection was defined as the time that elapsed from the collection of the blood specimen until the detection of a positive Gram stain. This was dependent on the routine examination schedules for both the manual and the automated systems.

Microorganisms isolated from blood were probable pathogens if the identity characterized the organism as rarely a contaminant or the identity of the microorganism was either a viridans group streptococcus or a coagulase-negative *Staphylococcus* spp. and either of these organisms was isolated from more than one blood culture receptacle in the same blood culture set. Bloodstream infections (septic episodes) were defined by using the criteria modified from those previously published by Kirkley and colleagues (6). To summarize, a bloodstream infection was defined as the initial isolation of a probable pathogen, the subsequent isolation of a different probable pathogen, or the isolation of the same probable pathogen after at least a 5-day interval since the previous first positive culture with that organism.

For each organism species (and overall), comparisons of the detection rates between any two given systems were assessed by the sign test. Paired comparisons of the time to detection between any two given systems were made by the Wilcoxon signed rank test. All calculated *P* values were two-sided, and *P* values of ≤0.05 were considered statistically significant.

RESULTS

The results of the study are provided in Tables 1 through 9. A total of 5,845 blood samples for culture met the criteria for inclusion in the study. Microbial growth was produced by 546 cultures (9.3%), and a total of 609 microorganisms were recovered from these 546 blood cultures. On the basis of our criteria for probable pathogens and contaminants, 434 of 609 microorganisms were considered probable pathogens; 175 microorganisms were considered probable contaminants.

The Isolator system detected significantly more total microorganisms (probable pathogens and probable contaminants), total probable pathogens, and total probable contaminants than either the ESP 80A or the Septi-Chek system (Tables 1 and 3). When assessing individual probable pathogens, the Isolator system detected significantly more *Staphylococcus aureus* and *Candida* sp. isolates than either the ESP 80A or the Septi-Chek system (Tables 1 and 3). Similarly, the Isolator system detected significantly more bloodstream infections (septic episodes) of *S. aureus* and *Candida* spp. than either the ESP 80A or the Septi-Chek system (Tables 4 and 6).

There were no statistical differences in total microorganisms (probable pathogens and probable contaminants), total probable pathogens, or total probable contaminants for the ESP 80A system when compared with those for the Septi-Chek system (Table 2). The ESP 80A system, however, detected significantly more isolates and episodes of bloodstream infec-

TABLE 2. Comparison of the ESP 80A system with the Septi-Chek system

Microorganism	No. of isolates detected by:				*P* value[b]
	Septi-Chek only	ESP 80A only	Both systems	Neither system[a]	
All microorganisms	92	69	229	219	NS[c] (0.083)
Probable pathogens					
All microorganisms	65	51	221	97	NS
Staphylococcus aureus	11	7	56	26	NS
Staphylococcus spp., coagulase negative	2	12	37	0	0.013
Streptococcus pneumoniae	0	1	3	0	NS
Streptococcus spp., viridans group	3	0	9	0	NS
Enterococcus spp.	2	5	10	9	NS
Escherichia coli	3	4	22	12	NS
Other members of the family *Enterobacteriaceae*	12	7	32	17	NS
Pseudomonas spp.	5	2	13	5	NS
Obligately anaerobic bacteria	9	1	4	8	0.022
Candida spp.	14	10	30	18	NS
Other fungi	1	0	0	0	NS
Other bacteria	3	2	5	2	NS
Probable contaminants					
All organisms	27	18	8	122	NS
Bacillus spp.	0	0	0	5	NS
Corynebacterium spp.[d]	1	1	2	8	NS
Propionibacterium spp.	4	0	3	1	NS
Lactobacillus spp.	0	0	0	1	NS
Other	3	1	3	9	NS
Staphylococcus spp., coagulase negative	19	11	0	95	NS
Streptococcus spp., viridans group	0	5	0	3	NS (0.063)

[a] Neither refers to the numbers of isolates detected only by the Isolator blood culture system.
[b] Refer to Materials and Methods for the method of calculation of *P* values.
[c] NS, not significant ($P > 0.05$).
[d] Does not include *Corynebacterium jeikeium.*

TABLE 3. Comparison of the Isolator with the Septi-Chek system

Microorganism	No. of isolates detected by:				*P* value[b]
	Isolator only	Septi-Chek only	Both systems	Neither system[a]	
All microorganisms	213	98	223	75	<0.001
Probable pathogens					
All microorganisms	98	66	220	50	0.015
Staphylococcus aureus	27	5	62	6	<0.001
Staphylococcus spp., coagulase negative	6	8	31	6	NS[c]
Streptococcus pneumoniae	0	2	1	1	NS
Streptococcus spp., viridans group	0	3	9	0	NS
Enterococcus spp.	10	3	9	4	NS (0.092)
Escherichia coli	9	6	19	7	NS
Other members of the family *Enterobacteriaceae*	13	11	33	11	NS
Pseudomonas spp.	6	4	14	1	NS
Obligately anaerobic bacteria	0	13	0	9	<0.001
Candida spp.	25	8	36	3	0.005
Other fungi	0	0	1	0	NS
Other bacteria	2	3	5	2	NS
Probable contaminants					
All organisms	115	32	3	25	<0.001
Bacillus spp.	5	0	0	0	NS (0.063)
Corynebacterium spp.[d]	7	3	0	2	NS
Propionibacterium spp.	0	7	0	1	0.016
Lactobacillus sp.	1	0	0	0	NS
Other	9	3	3	1	NS
Staphylococcus spp., coagulase negative	91	19	0	15	<0.001
Streptococcus spp., viridans group	2	0	0	6	NS

[a] Neither refers to the number of isolates detected only by the ESP 80A blood culture system.
[b] Refer to Materials and Methods for the methods of calculation of *P* values.
[c] NS, not significant ($P > 0.05$).
[d] Does not include *Corynebacterium jeikeium.*

TABLE 4. Summary of bloodstream infections detected by the Isolator and/or ESP 80A system[a]

Microorganism	No. of isolates detected				*P* value[b]
	Total by Isolator or ESP 80A, or both	By Isolator only	By ESP 80A only	By both systems	
All microorganisms	250[c]	59	47	144	NS[d]
Staphylococcus aureus	53	15	4	34	0.019
Staphylococcus spp., coagulase negative[e]	41	1	12	28	0.003
Streptococcus pneumoniae	4	0	3	1	NS
Streptococcus spp., viridans group[e]	5	0	0	5	NS
Enterococcus spp.	19	6	4	9	NS
Escherichia coli	26	5	5	16	NS
Other members of the family *Enterobacteriaceae*	37	11	7	19	NS
Pseudomonas spp.	17	7	2	8	NS
Obligately anaerobic bacteria	5	0	5	0	NS (0.063)
Candida spp.	36	12	3	21	0.035
Other fungi	1	1	0	0	NS
Other bacteria	6	1	2	3	NS

[a] Refer to Materials and Methods for the definition of bloodstream infection.
[b] Refer to Materials and Methods for the method of calculation of *P* values.
[c] Note that 379 probable pathogens isolated from 210 patients were detected by the Isolator or the ESP 80A system. These constituted 250 episodes.
[d] NS, not significant ($P > 0.05$).
[e] Refer to Materials and Methods for the categorization of these isolates as probable pathogens.

TABLE 5. Summary of bloodstream infections detected by the Septi-Chek and/or the ESP 80A system[a]

Microorganism	No. of isolates detected				*P* value[b]
	Total by Septi-Chek or ESP 80A, or both	By Septi-Chek only	By ESP 80A only	By both systems	
All microorganisms	229[c]	37	41	151	NS[d]
Staphylococcus aureus	42	4	6	32	NS
Staphylococcus spp., coagulase negative[e]	41	1	10	30	0.012
Streptococcus pneumoniae	4	0	1	3	NS
Streptococcus spp., viridans group[e]	8	3	0	5	NS
Enterococcus spp.	14	1	5	8	NS
Escherichia coli	23	2	3	18	NS
Other members of the family *Enterobacteriaceae*	33	7	6	20	NS
Pseudomonas spp.	15	5	2	8	NS
Obligately anaerobic bacteria	12	7	1	4	NS (0.070)
Candida spp.	29	4	6	19	NS
Other fungi	1	1	0	0	NS
Other bacteria	7	2	1	4	NS

[a] Refer to Materials and Methods for the definition of bloodstream infection.
[b] Refer to Materials and Methods for the method of calculation of *P* values.
[c] Note that 337 probable pathogens isolated from 194 patients were detected by the ESP 80A or the Septi-Chek system. These constituted 229 episodes.
[d] NS, not significant ($P > 0.05$).
[e] Refer to Materials and Methods for the categorization of these isolates as probable pathogens.

tion caused by probable pathogenic coagulase-negative staphylococci (Tables 2 and 5) than the Septi-Chek system.

In blood culture sets which produced growth of the same probable pathogens in the ESP 80A and Isolator systems, there

TABLE 6. Summary of bloodstream infections detected by the Isolator and/or Septi-Chek system[a]

Microorganism	No. of isolates detected				*P* value[b]
	Total by Isolator or Septi-Chek, or both	By Isolator only	By Septi-Chek only	By both systems	
All microorganisms	245[c]	58	42	145	NS[d]
Staphylococcus aureus	52	16	3	33	0.004
Staphylococcus spp., coagulase negative[e]	35	4	6	25	NS
Streptococcus pneumoniae	3	0	2	1	NS
Streptococcus spp., viridans group[e]	8	0	3	5	NS
Enterococcus spp.	17	8	2	7	NS
Escherichia coli	25	5	4	16	NS
Other members of the family *Enterobacteriaceae*	35	8	5	22	NS
Pseudomonas spp.	17	4	2	11	NS
Obligately anaerobic bacteria	11	0	11	0	0.001
Candida spp.	34	12	1	21	0.003
Other fungi	1	0	0	1	NS
Other bacteria	7	1	3	3	NS

[a] Refer to Materials and Methods for the definition of bloodstream infection.
[b] Refer to Materials and Methods for the method of calculation of *P* values.
[c] Note that 384 probable pathogens isolated from 207 patients were detected by the Isolator or the Septi-Chek system. These constituted 245 episodes.
[d] NS, not significant ($P > 0.05$).
[e] Refer to Materials and Methods for the categorization of these isolates as probable pathogens.

TABLE 7. Comparison of detection times of probable pathogens for matched ESP 80A and Isolator components

Microorganism (no. of isolates)	Median (mean) detection time (h)		Difference in detection times (h) between the two systems (I − E)		*P* value[a]
	Isolator (I)	ESP 80A (E)	Median (mean)	IQR[b]	
Escherichia coli (19)	24.0 (23.5)	16.0 (17.8)	7 (5.7)	1, 10	0.004
Other members of the family *Enterobacteriaceae* (28)	20.5 (24.3)	18.5 (24.8)	0 (−0.5)	0, 6	NS[c]
Pseudomonas spp. (11)	25.0 (34.3)	22.0 (36.5)	0 (−2.3)	0, 14	NS
Staphylococcus aureus (57)	21.0 (23.3)	24.0 (30.8)	0 (−7.5)	−3, 2	NS
Staphylococcus spp., coagulase negative (35)	27.0 (37.0)	24.0 (27.4)	2 (9.7)	0, 22	0.010
Enterococcus spp. (11)	19.0 (22.5)	16.0 (16.9)	0 (5.5)	0, 7	NS
Streptococcus spp., viridans group (9)	39.0 (42.0)	24.0 (52.0)	0 (−10.0)	−31, 14	NS
Candida spp. (35)	42.0 (42.0)	36.0 (47.8)	0 (−5.8)	−3, 9	NS
All probable pathogens (211)	24.0 (30.3)	23.0 (31.2)	0 (−0.9)	0, 8	NS (0.067)

[a] Refer to Materials and Methods for the methods of *P*-value calculations.
[b] IQR, interquantile range (25th, 75th percentiles).
[c] NS, not significant ($P > 0.05$).

was no significant difference in the median overall time to detection ($P = 0.067$), although significant differences were noted for *Escherichia coli* and coagulase-negative staphylococci (Table 7). However, a similar comparison showed the Isolator and the ESP 80A systems to have significantly shorter median detection times when they were independently compared with those for the Septi-Chek system for all microorganisms overall as well as for specific microorganism groups (Tables 8 and 9).

The Difco ESP 80A system had 29 (0.5%) false-positive signals. That is, the Gram staining of broth from bottles that produced a positive signal on the ESP instrument was negative and subculture of broth to solid medium produced no growth.

DISCUSSION

In the current study, we compared three aerobic blood culture systems simultaneously. The results of our study corroborate those from prior studies, one by Kirkley and colleagues (6) which compared the Isolator system exclusively with the ESP 80A system, and another by Henry and colleagues (2), which compared the Isolator system exclusively with the Septi-Chek system. Like our study, those studies showed that statistically significantly more isolates of *S. aureus* and *Candida* spp. were recovered from the Isolator system than from the ESP 80A or the Septi-Chek blood culture system. In another study, Kellogg and colleagues (4) showed that statistically significantly more isolates of *S. aureus* were recovered by the Isolator system than by the ESP 80A system; however, no statistically significant difference was observed for the isolation of *Candida* spp. Kirkley and colleagues (5) also compared the Isolator system with the Septi-Chek Release system. The Septi-Chek Release system, unlike the standard Septi-Chek bottle, but like the Isolator bottle, contains saponin, a lytic agent. Despite the addition of saponin in the Septi-Chek bottle, Kirkley et al. (5) observed that *S. aureus* and *Candida* spp. were detected statistically more frequently in the Isolator system than in the Septi-Chek Release system.

A concern about the Isolator blood culture system has been its relatively high rate of recovery of contaminating microorganisms, which is likely the result of the additional processing steps required for the Isolator system compared with the processing required for the broth systems (2, 6). Contaminated blood cultures significantly increase resource utilization and therefore add unnecessarily to the cost of medical care (1). For the current study, we considered any isolate of *S. aureus* to be a probable pathogen. This was based on a prior study by our group which determined that in the majority of cases the isolation of *S. aureus* only by the Isolator tube or only by the Septi-Chek bottle was clinically significant (2). In the current study, 22 isolates of *S. aureus* from 16 patients were recovered only by the Isolator system; in contrast, 2 isolates of *S. aureus* were recovered only by the ESP 80A system and 2 isolates were recovered only by the Septi-Chek system. For the 22 *S. aureus* isolates recovered only by the Isolator tube, in 11 instances only one colony of *S. aureus* was isolated. However, a review of

TABLE 8. Comparison of detection times of probable pathogens for matched ESP 80A and Septi-Chek components

Microorganism (no. of isolates)	Median (mean) detection time (h)		Difference in detection times (h) between the two systems (S − E)		*P* value[a]
	Septi-Chek (S)	ESP 80A (E)	Median (mean)	IQR[b]	
Escherichia coli (22)	24.0 (27.5)	16.0 (16.7)	7.5 (10.7)	0, 10	<0.001
Other members of the family *Enterobacteriaceae* (32)	24.5 (45.2)	18.0 (23.8)	8 (21.4)	0, 13	<0.001
Pseudomonas spp. (13)	39.0 (65.8)	24.0 (23.8)	19 (41.9)	10, 23	<0.001
Staphylococcus aureus (56)	28.0 (36.6)	23.5 (28.4)	7.5 (8.2)	0, 12.5	<0.001
Staphylococcus spp., coagulase negative (37)	43.0 (52.4)	25.0 (27.8)	14 (24.6)	5, 24	<0.001
Enterococcus spp. (10)	22.0 (21.4)	15.5 (16.9)	5 (4.5)	0, 7	0.031
Streptococcus spp., viridans group (9)	39.0 (71.9)	24.0 (52.0)	22 (19.9)	7, 24	0.008
Candida spp. (30)	96.0 (103.2)	36.0 (52.9)	48 (50.3)	24, 81	<0.001
All probable pathogens (221)	30.0 (52.6)	23.0 (31.4)	10 (21.2)	0, 24	<0.001

[a] Refer to Materials and Methods for the method of *P*-value calculations.
[b] IQR, Interquantile range (25th, 75th percentiles).

TABLE 9. Comparison of detection times of probable pathogens for matched Isolator and Septi-Chek components

Microorganism (no. of isolates)	Median (mean) detection time (h)		Difference in detection times (h) between the two systems (S − I)		*P* value[a]
	Septi-Chek (S)	Isolator (I)	Median (mean)	IQR[b]	
Escherichia coli (19)	24.0 (27.4)	24.0 (23.5)	0 (3.9)	0, 0	NS[c]
Other members of the family *Enterobacteriaceae* (33)	24.0 (63.4)	22.0 (26.8)	0 (36.6)	0, 11	NS
Pseudomonas spp. (14)	39.5 (56.2)	26.5 (35.6)	4.5 (20.6)	0, 24	NS
Staphylococcus aureus (62)	31.0 (50.1)	22.5 (25.8)	10 (24.3)	0, 24	<0.001
Staphylococcus spp., coagulase negative (31)	43.0 (49.9)	25.0 (32.9)	3 (17.0)	0, 24	0.007
Enterococcus spp. (9)	23.0 (21.4)	15.0 (20.6)	0 (0.9)	0, 6	NS
Streptococcus spp., viridans group (9)	39.0 (71.9)	39.0 (42.0)	6 (29.9)	0, 79	NS (0.063)
Candida spp. (36)	96.0 (112.7)	43.5 (41.9)	57.5 (70.8)	24, 89	<0.001
All probable pathogens (220)	31.0 (61.0)	24.0 (31.0)	9 (30.0)	0, 36.5	<0.001

[a] Refer to Materials and Methods for method of *P*-value calculations.
[b] IQR, interquantile range (25th, 75th percentiles).
[c] NS, not significant ($P > 0.05$).

the medical records of patients from whom only one colony of *S. aureus* was recovered by the Isolator system revealed that for the majority of patients (10 of 11) this result was clinically significant. On the basis of our definition of probable contaminants which excluded *S. aureus* isolates, our results showed that the Isolator system recovered statistically significantly more probable contaminants than either the ESP 80A ($P < 0.001$) or the Septi-Chek ($P < 0.001$) system (Tables 1 and 3).

We did not evaluate the recovery of *Candida* spp. from the anaerobic component of the Difco ESP automated blood culture system, the ESP 80N bottle. Of interest, Morello and colleagues (7) demonstrated the recovery of a significant number of *Candida* sp. isolates by the ESP 80N bottle. Furthermore, Kellogg and colleagues (4) showed no statistical difference in the recovery of *Candida* spp. when the Isolator system was compared with the ESP 80A and 80N bottles used in combination. In the study by Kellogg et al. (4), *Candida* sp. isolates were recovered by ESP 80N bottles as well as from ESP 80A bottles. Had we also evaluated the ESP 80N bottle, there may have been less or no difference in the isolation of *Candida* spp. between the Isolator and the ESP systems (ESP 80A and 80N bottles combined).

In our study, obligately anaerobic bacteria were not recovered by the Isolator system. This was not surprising because the plates inoculated from the Isolator sediment were not incubated in an anaerobic environment. In contrast, obligately anaerobic bacteria were recovered occasionally from both aerobic broth systems. This has been reported previously by us (3) for the Septi-Chek system and by Morello and colleagues (7) for the ESP 80A system.

The continuous monitoring feature of the ESP system resulted in comparable median times for the detection of microorganisms when compared with the median times for detection by the Isolator system. Both the ESP 80A and Isolator systems had considerably shorter median times for the detection of microorganisms compared with those for the Septi-Chek system. The amount of technologist time required for the processing of blood cultures, including accessioning of all cultures, centrifugation and plating of Isolator sediment, placement of culture plates or bottles in the incubator or, in the case of ESP 80A, of bottles into the ESP instrument, and evaluation of manual culture plates or bottles, varied considerably. Considering all of these procedures, the ESP 80A system required the least amount of processing time compared with the Septi-Chek or the Isolator system.

In summary, for the three aerobic blood culture systems prospectively evaluated (the Isolator, ESP 80A, and Septi-Chek systems), the Isolator system detected statistically significantly more isolates and bloodstream infections caused by *S. aureus* and *Candida* spp. Both the ESP 80A and Septi-Chek systems had comparable contamination rates which were statistically significantly less than that for the Isolator system. The Isolator and ESP 80A systems had statistically significantly shorter median detection times than that of the Septi-Chek system. The ESP 80A system had relatively few false-positive signals, and by virtue of automation, it required less hands-on time than either the Isolator or the Septi-Chek system.

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