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Impact of the BACTEC NR System in Detecting *Candida* Fungemia

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As a result of the growing importance of candidemia, various techniques for the detection of *Candida* spp. in blood have been designed with a view to speeding up the laboratory procedure. We have performed a retrospective comparison of the efficiencies of the conventional VACUTAINER system (Becton Dickinson Vacutainer Systems) and the BACTEC NR system (Johnston Laboratories, Inc.). During a 4-year period, 88,300 blood cultures were processed, with growth of *Candida* species in 552. The mean times required for the detection of growth were 7.55 days with the VACUTAINER system and 4.1 days with the BACTEC NR system ($P < 0.05$). During the first week of incubation, the VACUTAINER system detected 56.1% of the candidemias and the BACTEC NR detected 93.6% ($P < 0.05$). Use of the BACTEC NR therefore permits reduction of the incubation period from the previously established 4 weeks to a more convenient 7 to 14 days.

Candida fungemia, a growing nosocomial problem (20, 22), is frequently the only evidence of systemic candidiasis. The detection of candidemia by conventional blood culture procedures (nonautomated monophasic systems) is, however, rather slow and requires prolonged incubation periods (14, 24). More specific blood culture techniques, designed to reduce these delays, involve the introduction of special media (2, 3, 7, 16, 27), the alteration of well-established work routines (6, 10–12, 18, 19, 26), or the application of lysis-centrifugation, with its well-known time-consuming procedure (1, 4, 5, 17).

The detection of *Candida* spp. in blood cultures by the radiometric system (BACTEC R) has been shown to be superior to the conventional methods with regard to productivity and shorter times of detection of positive bottles (13, 21, 25). With the introduction of the nonradiometric system (BACTEC NR) into many laboratories (9, 15) and the increasing importance of candidemia in recent years, an assessment of this method has become necessary.

We compared retrospectively the efficiency of the BACTEC NR system in the recovery of *Candida* spp. with that of the conventional method previously used (VACUTA INER).

The method selected for comparison of the two systems was a retrospective review of the data obtained simultaneously from the microbiology laboratories of two large teaching hospitals in Madrid, Spain (Hospital Universitario de San Carlos and the Hospital General Gregorio Marañón) performed between 1 October 1984 and 31 December 1987. Until the first quarter of 1986, the VACUTAINER blood culture system (Becton Dickinson Vacutainer Systems) was used in both hospitals. This was then substituted by the BACTEC NR system (Johnston Laboratories, Inc.). In both hospitals, the processing of blood cultures with the VACUTAINER system was carried out by standard methods, employing the acridine orange stain for confirmation of suspicion of growth, and with the corresponding subcultures at 7 days of incubation. Blood cultures were processed by the BACTEC system according to the instructions of the manufacturer. In all cases with clinical suspicion of endocarditis, fungemia, or brucellosis, blood cultures were maintained for a month. Subcultures (VACUTAINER) or automated readings (BACTEC) were performed at weekly intervals. With the BACTEC system, if the reading showed no indication of growth (less than 30 U), subculturing after incubation was not performed. The identification of *Candida* spp. at both generic and species levels was carried out according to conventional methods (8).

In cases in which the blood cultures were positive for *Candida* sp., a preestablished protocol was completed, including the name of the patient, the lapse of time before detection of growth, the type of bottle (vented or not), the *Candida* species isolated, and the type of blood culture technique employed.

Statistical comparison was done by using the chi-square test. The Student *t* test was used to compare quantitative variables whenever necessary. Statistical significance was considered to exist when the *P* value was <0.05.

During the study period a total of 88,330 blood cultures were processed, with growth of *Candida* species in 552 (0.6%), from 126 patients who presented with 137 episodes of candidemia. Since no significant difference was found between the two hospitals, all comments will refer to both, without distinction.

Candida albicans was identified in 284 bottles in a mean time of 5.25 ± 3.85 days, while the remaining 268 *Candida* isolates were detected in a mean time of 6.77 ± 3.83 days ($P < 0.05$). Table 1 shows the more noteworthy results. With the VACUTAINER system, the mean time required for the detection of growth was 7.55 ± 4.06 days (95% confidence interval, 7.10 to 8), while with the BACTEC NR system the mean time was 4.1 ± 2.66 days (95% confidence interval, 3.78 to 4.42) ($P < 0.05$).

During the first week of incubation, the VACUTAINER and BACTEC NR systems detected positivity in 56.1 and 93.6% ($P < 0.05$), respectively, of the blood cultures showing growth of *Candida* spp. The different *Candida* species identified and the respective mean times of their detection are shown in Table 2.

During recent years many varieties of blood culture systems have been introduced to improve the rate of recovery

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TABLE 1. Correlation between VACUTAINER and BACTEC NR results

Characteristic	Results obtained with:	
	VACUTAINER	BACTEC NR
No. (%) of blood cultures		
Total	38,593	49,737
Positive for *Candida* species	303 (0.78)	249 (0.5)
Mean time (days) of growth ± SD		
All *Candida* species	7.55 ± 4.06	4.1 ± 2.66[a]
C. albicans	7.17 ± 4.47	4.0 ± 2.91[a]
Other *Candida* species	7.47 ± 3.97	4.1 ± 1.50[a]
% Detected within:		
7 days	56.1	93.6[a]
14 days	96.3	99.6[b]
Vented/nonvented bottles	293/10	248/1[a]
No. (%) positive for:		
C. albicans	92 (30)	192 (77)[a]
Other *Candida* species	211 (70)	57 (23)[a]

[a] $P < 0.05$.
[b] No significant differences.

of fungi from blood (23). Some of these, based on conventional systems, have the disadvantage of requiring separate incubation and examination routines when candidemia is suspected, thus increasing the workload in busy laboratories (2, 3, 6, 7, 10, 12, 16, 18, 19, 26, 27). Others, such as those based on lysis-centrifugation, are time-consuming and have a high index of contamination (1, 4, 5, 17).

The introduction of the radiometric detection procedure (BACTEC R) has permitted the establishment of a mechanized routine which has demonstrated greater sensitivity in the detection of candidemia than that displayed by conventional systems (13, 21, 25). The radiometric system, nevertheless, has the drawbacks inherent in the handling of radioactive materials.

The new, automated, nonradiometric BACTEC system (BACTEC NR) is a very convenient and reliable procedure for the detection of bacteremia (9, 15), but, to our knowledge, no information regarding its efficiency in the diagnosis of candidemia is available. Our data show a significant reduction in the time required for the detection of candidemia, to a mean period of 4.1 days, with 93.6% of all recognized candidemias detected by the end of the first week of incubation. These figures show a significant improvement over those obtained with the standard VACUTAINER system (56.1% detection during the first 7 days of incubation and a mean time of growth of 7.55 days). Although our study did not include a comparison of costs, a disadvantage of the BACTEC NR system seems to be the cost of materials, which, in our country, is almost twice that of the VACUTAINER system. Nevertheless, the saving in work hours probably compensates for the cost.

TABLE 2. Correlation between *Candida* or *Torulopsis* species and mean times of growth

Species	VACUTAINER		BACTEC	
	No. of isolates	Mean time (days) of growth ± SD	No. of isolates	Mean time (days) of growth ± SD
Candida albicans	92	7.17 ± 4.27	192	4.08 ± 2.92
Candida tropicalis	55	8.16 ± 4.73	20	3.85 ± 1.31
Candida parapsilosis	45	7.20 ± 5.01	18	4.67 ± 2.06
Torulopsis glabrata	36	7.65 ± 3.46	8	4.12 ± 0.35
Candida rugosa	11	6.82 ± 3.16		
Candida krusei	3	5.00 ± 0.00	3	4.00 ± 0.00
Candida stellatoidea	3	6.33 ± 2.31		
Torulopsis candida			3	3.00 ± 0.00
Candida guilliermondii	3	5.00 ± 3.46		
Candida lipolytica	2	12.5 ± 2.12		
Candida pseudotropicalis			2	6.00 ± 0.00
Candida sp.	53	7.15 ± 2.44	3	3.67 ± 1.15

Our study has shown significant differences between the two systems in the detection of the diverse *Candida* species. These differences may be due to a simultaneous change in epidemiology in the two hospitals or, more probably, to differences in the capacities of the two systems to detect candidemia caused by the different species. Further comparative studies of the two systems in parallel, with the same group of patients, are required to clarify this point. Until such studies are done, the apparent difference between the two systems should be borne in mind.

According to our data, in cases of suspected candidemia, the use of the BACTEC NR system permits the reduction of the generally accepted period of blood culture incubation from 4 weeks to a more convenient 7 to 14 days, with considerable benefits to both patients and laboratory staff.

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