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More rapid identification of bacteraemia by manual rather than radiometric method

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SUMMARY Results of blood culture examination using the radiometric (Bactec-460) system for one year showed no overall improvement compared with those of the previous three years when a manual system with early blind subculture was used. The isolates from the manual system were available more often on solid media, 24 hours earlier, than when the radiometric system was used. In a further study of 1100 blood cultures the radiometric medium was tested for growth index as well as being subcultured blindly, irrespective of growth index, on the first day. Thirty six out of 54 (67%) of the blood cultures were positive on subculture but negative for growth index at this time. The overall cost of the radiometric system is also considerably more than that of the manual system.

Detection of bacteraemia by means of the semi-automated radiometric Bactec-460 system (Johnston Laboratories, United States) is increasingly being accepted as a routine procedure in clinical laboratories. It is reported as being faster and more sensitive than manual methods.[1 2] We analysed the time taken to detect bacteraemia using the Bactec system for one year and compared this with data from the previous three years when a manual system was used that included early blind subcultures. We also present results of a prospective study comparing the radiometric and conventional blood culture detection systems in parallel.

Material and methods

CULTURE MEDIA

Bactec media phials 6B and 7C were used as aerobic and anaerobic media in the radiometric system. The media used in our conventional system were as reported previously[3]: they consisted of a biphasic aerobic medium with Columbia agar (Lab M, Salford) as the solid phase and brain-heart infusion broth (Lab M) containing polyanethol sulphonate (Liquoid, Roche) 0·25% and thymidine (BDH) 0·4% as the liquid phase. The anaerobic medium used was fastidious anaerobe broth (FAB, Lab M). The volume of blood cultured in both systems was similar.

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SUBCULTURES

Bactec media were used in accordance with the manufacturer's instructions but with an additional test at 10 pm on the first day. Aerobic phials were tested three times on the day the sample was received in the laboratory (day 1). Cultures taken between 5 pm and 9 am were tested at 9 am and 4 pm. Cultures received between 9 am and 5 pm were tested at 10 pm. All cultures, including anaerobic phials, were tested twice on day 2, at 9 am and 4 pm, and once on days 3, 4, and 7. We omitted testing on days 5 and 6 as a previous investigation had shown this to be less useful. Blood cultures taken between 5 pm and 9 am were incubated without delay in incubators within easy reach of medical staff and collected by laboratory staff at 9 am. A growth index $\geqslant 30$ in the aerobic phial and $\geqslant 15$ in the anaerobic phial, or a rise of $\geqslant 10$ between two consecutive readings in either bottle, was considered to be positive, and a Gram film and subculture were made.

We used the routine previously described for our manual system with early blind subculture. Cultures were examined visually at 9 am each day. The biphasic medium was subcultured twice by tilting, and, in addition, the fastidious anaerobic broth medium was subcultured blind at 10 pm on day 1. Further blind subcultures of fastidious anaerobic broth were performed at 9 am on days 2, 4, and 7, when finally, both bottles were opened and subcultured. Reporting times in the manual system were based on microscopy or results of blind subcultures and those for the Bactec on growth index readings and microscopy.

Table 1 *Time taken to detect patients with bacteraemia (1980–83)*

	Manual system			*Bactec system*
	1980	*1981*	*1982*	*1983*
No of blood culture sets	3282	3749	4820	6411
No of patients examined	1515	1656	2071	3249
No of patients with bacteraemia (%)	117	120	171	207
Reported by 10 pm day 1	16 (14)	23 (19)	35 (21)†	73 (35)†
Positive after blind subculture on day 1	48 (41)	32 (27)	55 (32)	ND
Growth on solid medium within 24 hours	64 (55)	55 (46)	90 (53)‡	73 (35)‡
Additional positives at 9 am, day 2	14 (12)	34 (28)	44 (26)*	98 (47)*
Total reported in 24 hours	78 (67)	89 (74)	134 (78)**	171 (83)**

ND = not done.
Significance †$p < 0.01$, ‡<0.025, *<0.001, **not significant.

Table 2 *Comparison of blind subculture and growth index reading in 1100 radiometric blood cultures*

	Positive at			*Total (%)*
	4 pm	*7 pm*	*10 pm*	
Subculture positive but growth index negative	9	5	22	36 (67)*
Both methods positive	9	3	6	18 (33)*
Total of positive cultures	18	8	28	54

*Significance $p < 0.05$.

In the subsequent comparative study of 1100 blood cultures the aerobic 6B phial was subcultured blindly irrespective of growth index readings and tested as shown above on day 1. Cultures received between 5 pm and 9 am were subcultured at 4 pm (seven to 23 hours of incubation), and those received between 9 am and 5 pm were subcultured at 10 pm (five to 13 hours of incubation). During the weekend and on bank holidays blind subcultures were done at 7 pm only. The Bactec 6B phials were also tested for growth index readings at these times.

Results

Table 1 shows the time taken to detect clinically important bacteraemia in patients during four consecutive years. In 1982, using our manual system, we reported 90 out of 171 (53%) cases of bacteraemia on the basis of cultures on a solid medium within 24 hours. This figure is similar to that in our previously reported study.[3] The corresponding figure in 1983, using the Bactec, was only 73 out of 207 (35%). This difference is significant. Taking the additional sample for radiometry at 10 pm on the first day, which is not a recommended procedure for Bactec, 23 (11%) more positive results were reported. The total detection rate by the Bactec system as reported by 10 pm on day 1 was 35% compared with 21% for the manual system ($p < 0.01$). The figure of 35% includes results from a sampling at 4 pm and 10 pm using the Bactec system. We did not subculture at 4 pm with the manual system. Most positive cultures recorded by the Bactec system were detected radiometrically at 9 am on day 2, at which time a tentative result based on microscopy only was possible. The total detection rate over 24 hours using Bactec did not differ significantly from that in the previous year using the manual system.

In the comparative parallel study 1100 radiometric blood cultures were examined and 54 found to be positive. In 36 (67%) of these the Bactec bottles were positive after blind subculture but negative for growth index on day 1 (Table 2). The organisms isolated from the 36 radiometric blood cultures are shown in Table 3. These cultures gave a positive growth index reading the next morning at 9 am (11 to 17 hours later), at which time growth was visible on subcultured plates.

Table 3 *Organisms isolated from 36 blood cultures positive on subculture but negative for growth index*

Organisms	*No of isolations*
Staphylococcus aureus	8
Staphylococcus epidermidis	4
Streptococcus spp (Lancefield group D)	5
Escherichia coli	4
Klebsiella aerogenes	4
Serratia marcescens	3
Streptococcus pneumoniae	1
Morganella morganii	1
Proteus mirabilis and *Escherichia coli*	1
Proteus mirabilis and *Staphylococcus aureus*	1
Streptococcus mitis	1
**Serratia* sp and *Klebsiella ozaenae*	1
**Serratia* sp and *Acinetobacter calcoaceticus var anitratus*	1
**Klebsiella oxytoca* and *Acinetobacter calcoaceticus var anitratus*	1
Total	36

*Probable contaminants.

Table 4 *Comparison of approximate annual costs (£) for 6411 blood culture sets**

Manual system		*Bactec system*		
			Leased	Purchased
Fastidious anaerobe broth medium	3213†	6B	7234	7234
Biphasic medium	2127	7D	7234	7234
Medical laboratory scientific officer (1)	8162	Medical laboratory scientific officer (1)	8162	8162
Laboratory assistants (1½)	6764			
Subculture at 10 pm "on call"‡	3041	Subculture at 10 pm "on call"‡	3041	3041
Four "blind" subcultures	3044	Leasing charge	7320	
		Bactec capital depreciation§		4774
		Maintenance	1452	1452
		Bottle crusher depreciation§	200	200
Total	26 351		34 643	32 097

*Prices at April 1985 include VAT, exclude laboratory overheads.
†Includes current discount and delivery charge.
‡At £8.33 per day.
§Over five years.

Discussion

The rapid rise in the number of laboratories—now more than 100 in the United Kingdom[4]—using the radiometric semiautomated Bactec-460 system reflects the documented conception that this system is more efficient than conventional methods and also saves the time of technical staff. We agree that the semiautomation makes sampling quicker and less tedious when dealing with large numbers of cultures. Published reports of the superiority of the radiometric system are based on comparative data using a manual system with inadequate media and few or no early blind subcultures.[2 5 6] Thus in a recent study a very low detection rate of 9·5% (at 24 hours with the manual system) rose to 76% with the Bactec system.[2] Our considerably higher manual detection rate of 78% may be due to the use of an efficient biphasic aerobic medium in parallel with a sensitive anaerobic medium, incubation without delay outside laboratory hours, and early blind subculturing.

A comparison of the radiometric with conventional blood culture systems depends on the adequacy of each system, and both continue to be improved. In our experience reporting times were similar with the manual and the radiometric systems. Our preference for early blind subculturing is because the isolate is then available on solid medium 24 hours earlier than with the Bactec system. This enables preliminary identification and the choice of a more specific, narrower spectrum antibiotic. A blind early subculture of Bactec 6B phials gives quicker results than radiometric detection but defeats the purpose of semiautomation.

We observed Bactec phials showing negative growth indexes yet with visual evidence of heavy bacterial growth, including a carpet of colonies and turbidity and numerous organisms on microscopy. This emphasises the importance of critical visual examination with the Bactec as with all other blood culture systems. This was most evident in the unshaken anaerobic bottles. In aerobic bottles, however, the recommended use of the shaker in the first 24 hours obscured this effect, although the shaker often proved to be mechanically unreliable. Conclusive evidence of the relative insensitivity of the radiometric system was provided by the results of our prospective parallel study of 1100 blood cultures, when 67% of the positives on the first day were negative for growth index.

Table 4 shows that the costs of investigating 6411 blood culture sets by the Bactec system are considerably higher than those of our manual system. This is despite estimations for a generous amount of staff time for preparing biphasic medium and doing blind subcultures in the manual system. The comparative costs reported from the United States show the Bactec system to be relatively even more expensive.[1]

Further disadvantages of the Bactec are the small maximum volume (3–5 ml) of blood cultured, the dependence on American media, the use of radioactive materials (although of low intensity), and the economic burden of being tied to the United States exchange rate. Despite these important disadvantages semiautomation is an attractive feature of the Bactec system because it facilitates the handling of large numbers of specimens.

We conclude that the overall detection rate with the Bactec-460 system, though convenient, is no better than that with our manual system. Moreover the radiometric detection system is comparatively insensitive as, in the absence of a significant growth index, early blind subculture yields positive results on solid media.

An interesting modification incorporated in the new Bactec NR-660 is the replacement of the radiometric by an infrared detection system. This

new system, however, still depends on adequate production of gas, and its sensitivity has yet to be evaluated.

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