Bacteriological examination of removed cerebrospinal fluid shunts

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SUMMARY   A conventional method of bacteriological examination of removed cerebrospinal fluid shunts was compared with another method which relies on microscopic and cultural examination of intraluminal fluid. Fifty-five shunts were tested. All eight cases of clinical shunt infection gave positive results with the latter method, whereas a further 23 shunts yielded positive cultures by the conventional method in the absence of clinical infection. The consequences of missed infections due to omission of microscopic examination and overdiagnosis using the conventional culture method are discussed.

Since 1957, silicone rubber shunts have been used to treat hydrocephalus.

Within a few years of the first publications describing their use[1][2] reports of bacteraemia due to shunt colonisation appeared.[3-5] Infection of both ventriculoatrial (VA) and ventriculoperitoneal (VP) shunts is now a well-recognised problem, with a reported incidence of between less than 1% and 35% of operations performed. In most published series, the organisms responsible for most infections are the coagulase-negative staphylococci (*Staphylococcus albus*), with a smaller proportion of *Staph aureus*, corynebacteria, propionibacteria, non-haemolytic streptococci, yeasts and coliforms being reported. All of these organisms are common members of the skin flora, particularly of patients in hospital, and consequently they appear as contaminants in a proportion of all clinical specimens. Bacteria representing the skin flora can be found in most surgical incisions prior to closure,[6] and in incisions for shunt insertion and revision.[7] It is therefore to be expected that the external surfaces of cerebrospinal fluid shunts may on occasion become contaminated during removal, even in the absence of infection. A telephone survey of 28 laboratories in the United Kingdom confirmed our view that the most common method of examination of removed CSF shunts is to immerse the shunt in a fluid culture medium, and after overnight incubation to subculture onto solid media. The media and incubation time varied and anaerobic cultures were usually omitted.

The underlying pathology which made shunting necessary often makes clinical diagnosis of shunt infection difficult, especially as the classic features are frequently absent in the early stages. Malfunctioning VA shunts are frequently revised to VP, and malfunctioning VP shunts are often resited in the abdomen after freeing of adhesions. In the absence of serological studies,[8-10] shunt infection may not be suspected prior to surgical removal or revision for malfunction. However, an infected VP shunt which is merely resited will require reoperation in a matter of weeks because of peritonitis or malfunction due to peritoneal cyst formation.[8] Partial revision of an infected VA shunt for malfunction will lead to persistence of the infection and, if this continues to go unrecognised, to immune complex nephritis.[10][11] The need for bacteriological examination of removed shunts is therefore evident. However, unnecessary extension of hospital stay and antibiotic therapy, and in some cases unnecessary surgery, may be consequences of cultural methods which yield results suggesting infection which are in fact due to contamination. For these reasons alone, we consider careful examination of all removed shunt components, irrespective of the reasons for removal, to be essential.

Another reason is the need for collection of accurate data on shunt infections, particularly where these form a part of national statistics. We believe that, due to the lack of reliable clinical information or lack of time to obtain it, many such statistics are based solely on the results of the conventional method of examination.

We have therefore compared a method of examination developed and used in our laboratory (method

A) with the conventional method outlined above (method B) to see whether erroneous diagnosis can be avoided.

Material and methods

METHOD A

The CSF shunt or its component parts were aseptically removed from the sterile glass jar in which they were received and placed in a sterile stainless steel dish. The device was then examined and the type noted. Any tissue or pus on the outside of the shunt was swabbed and examined by Gram stain and culture. Before sampling, a portion of the surface of the component to be aspirated was thoroughly cleaned with a swab containing isopropanol, and fluid was aspirated from the lumen of the component using a syringe and needle. If an open-ended catheter was received, a pasteur pipette was introduced into one end and the luminal fluid aspirated. If there was no luminal fluid, approximately 0·1 ml of sterile distilled water was introduced and aspirated. The ventricular catheter, if present, was sampled, followed by the valve chamber in the case of a shunt with a proximal valve such as Holter, Hakim or Denver, followed by the distal catheter. The fluid from each component was processed separately. One drop was placed on a microscope slide for Gram stain, one drop was inoculated onto a blood agar plate for direct aerobic incubation, and the remainder was inoculated into a cooked meat broth. After incubation for two days this was subcultured aerobically and anaerobically on blood agar. Changes in incubation times and media were made if indicated by the Gram stain.

METHOD B

After sampling using method A was completed, the shunt was processed by the conventional method, by aseptically placing it into cooked meat broth. After two days this was subcultured aerobically and anaerobically.

Identification of organisms

Coagulase-negative staphylococci were tested for production of deoxyribonuclease[12][13] and, if negative, identified using the "API Staph" system. They were also tested for sensitivity to a range of antimicrobials, and a numerical antibiogram ("Sensitype") was derived as shown in Table 1.

Criteria for diagnosis of clinical shunt infection

These included the finding of bacteria on Gram stain and culture of CSF aspirated from the shunt or reservoir prior to removal, along with serological evidence[8–10] and clinical features, though the classic

features of shunt infection were frequently absent.

Results

The results of bacteriological examination of 55 CSF shunts by methods A and B are shown in Tables 2 and 3. Nine shunts were considered positive by method A and eight of these were clinically infected. The exception (RM) had two revisions. At the first revision *Staphylococcus albus* was isolated by method A but only on secondary culture. The Gram film was negative and there was no clinical evidence of shunt infection. At the second revision the same organism was isolated by method A primary culture and there was clinical evidence of shunt infection. Patient NC was also negative by Gram film but positive on culture by method A. Patient BD and Patient EP (second revision) had organisms in the Gram film but culture by method A was negative, probably because they were receiving antibiotics.

Eight of the nine shunts which were positive by method A were positive by method B; the exception was patient BD. Twenty-three shunts were positive by method B only, and none of these was clinically infected.

Table 3 shows the detailed results of examination of the eight infected shunts by method A. One was due to *Staph aureus*, four were due to *Staph albus* and in two, no organisms were isolated though they were seen in the Gram film. One patient (LS) had a grossly infected extracranial collection of CSF around the shunt which yielded five organisms when aspirated preoperatively. *Staph aureus* was isolated from the

Table 1   *Derivation of numerical antibiogram*

P	T	C	E	Clo	Tr	Cli	Ge	Ri
4	2	1	4	2	1	4	2	1

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$$7 \qquad\qquad 7 \qquad\qquad 7$$

Resistance to a drug scores as shown and triplets are added to give a numerical antibiogram.
For example, resistance to P T Ge = 602

P = penicillin	Tr = trimethoprim
T = tetracycline	Cli = clindamycin
C = chloramphenicol	Ge = gentamicin
E = erythromycin	Ri = rifampicin
Clo = cloxacillin	

Table 2   *Results of bacteriological examination of 55 shunts*

Method	Total positive	Clinically infected
A	9	8
B	31	7
A alone	1	1
B alone	23	0

Table 3 *Results of positives by Method A, all clinically infected*

Patient	Site	Gram	Culture
BD*	LC	+C +++	NG
KD	VC, V	+C ++++	Staph aureus
EC	VC	+C ++++	Staph albus
LS	VC	+C +, −B +	Staph aureus, Ps aeruginosa
	V	+C +	Staph aureus
EP* (2)°	VC	+C +	NG
PC	VC, V, LC	+C ++	Staph albus
RM (2)°	VC, LC	+C ++	Staph albus
NC*	VC	NOS	Staph albus

VC = ventricular catheter +C = Gram-positive cocci
LC = lower catheter −B = Gram-negative bacilli
V = valve chamber NOS = No organisms seen
NG = no growth
° = the second of two revisions * Patients on antibiotics

fluid from the valve chamber, and *Staph aureus* and *Pseudomonas aeruginosa* were isolated from the fluid in the upper catheter. The shunt was malfunctioning.

Table 4 shows the detailed results of those shunts which were positive by method B, and culture results by method A are included for comparison. Patient BD, who was clinically infected and whose shunt fluid microscopy was positive but whose culture by both methods failed to grow any organisms, is included for completeness. On the basis of the sensitypes, it can be

seen that the same strain which was isolated in the infected cases by method A was also isolated by method B, though the latter method often yielded more than one organism.

Discussion

The results show that the conventional method of examining removed shunts yielded positive cultures from 42% whereas the use of method A resulted in 16% which showed organisms either by microscopy or on culture of the fluid inside the shunt.

In three patients, with shunt infections who were receiving antibiotics there was no correlation between microscopy and culture by method A. In one case (BD) the infection would not have been detected had microscopy been omitted. In a further case RM (first revision) examination using method A showed no organisms in the Gram film or on the primary culture but grew *Staph albus* (sensitype 440) from the secondary culture. This strain, along with another, was isolated by method B. The patient later developed features of shunt colonisation and *Staph albus*, sensitype 440, was isolated from the ventricular CSF before shunt removal as well as from the fluid

Table 4 *Comparison of the culture results of CSF shunts by two methods*

Patient	Site	Culture (method B)		Culture (method A)
HD	LC	Staph albus	200	NG
CO	VC, LC	Staph albus	400	NG
CB	VC	Staph albus	410, Diphtheroid	NG
JP	LC	Staph albus	402	NG
KD	VC	Staph albus	400	NG
UC	VC	Staph albus	410, 500, 600	NG
KD*	VC, V	Staph aureus	400	Staph aureus 400
CO	VC, V, LC	Staph aureus	610, Bacillus sp	NG
EC*	VC	Staph albus	443, 662	Staph albus 443
JG	LC	Staph albus	600	NG
SP	VC, V	Staph albus	440, 540	NG
CO	VC	Diphtheroid		NG
FA	VC	Micro luteus	000	NG
DT	V, LC	Staph albus	000	NG
DB	VC, V	Staph albus	400	NG
EP (1)	LC	Staph albus	400	NG
LS*	VC, V	Staph aureus	410, Ps aeruginosa	Staph aureus 410
		Klebsiella, E coli,	Strep faecalis	Ps aeruginosa
EP (2)*	UC	Staph albus	453	NG (Gram film +C +)
PC*	VC, V, LC	Staph albus	000	Staph albus 000
SA	V, LC	Staph albus	000	NG
MG	VC	Staph albus	400	NG
RM (1)	VC, V	Staph albus	400, 440	2° Culture only Staph albus 440
CS	VC, V, LC	Staph albus	400, 410, Diphtheroid	NG
DM	LC	Staph albus	020	NG
NB	LC	Staph albus	000, 010, 420, 600	NG
RM (2)*	VC, LC	Staph albus	000, 440, Strep viridans	Staph albus 440
JB	VC	Staph albus	000	NG
DM	LC	Staph albus	510, 650, Bacillus sp × 2	NG
SA	VC	Staph albus	020	NG
DP	VC	Staph albus	000	NG
NC*	VC	Staph albus	510	Staph albus 510
BD*	LC	NG		NG (Gram film +C +++)

* clinically infected cases.
Numbers following organisms refer to sensitype.
All other abbreviations as in Table 3.

inside the second removed shunt (Table 4). While it is impossible to say whether the first shunt from which growth was obtained only on sub-culture was infected, we consider it more likely that the fluid inside the removed shunt was accidentally contaminated either during removal by organisms in the incision, or during laboratory sampling by organisms from the outer surface of the shunt. The subsequent infection of the second shunt was probably due to its contamination during revision, also by organisms present in the incision, and it would not be surprising that the same organisms were involved in these events.

None of those cases positive only by method B showed evidence of infection. Presumably at least some of those which yielded pure cultures using method B would have been reported as shunt infections by laboratories using this method.

We believe that examination of a Gram film is important, and this view is supported by the two cases where organisms were seen on microscopy but failed to grow on culture due to antibiotic treatment. Another reason for the inclusion of the Gram film is that some organisms responsible for shunt infections may require more than two days' incubation to grow, and this is particularly true of some diphtheroids.[14] Where such organisms are seen in a Gram film of intraluminal fluid, culture methods may be changed or incubation times extended in order to ensure their isolation. For example *Propionibacterium acnes* is an occasional but important cause of shunt infection and prolonged anaerobic culture has been recommended[15] where the presence of this organism is suspected.

Shunt infections may be divided into two groups. The first group, external to the shunt and not extending to its lumen, are usually caused by *Staph aureus* or coliforms. These are wound infections or, rarely, secondarily infected collections of CSF. In such cases the fluid inside the shunt will give negative results unless either the shunt lumen has become infected before removal by needle aspiration through the infected area, or has been contaminated in the laboratory by organisms from the external surfaces of the shunt. As such external infections are almost always clinically obvious, and pus can usually be aspirated or collected at operation, the exclusive use of method A should not result in their not being detected and properly investigated.

The second group, designated internal infections, which are far more common in most units and are usually due to *Staph albus*, *Staph aureus* or diphtheroids, represent true shunt infection. Our results suggest that, in this group, the exclusive use of method B will result in over-diagnosis of shunt in-

fection, whereas the use of both methods, or the exclusive use of method A, will yield more accurate information on which to base a diagnosis.

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