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# Analysis of results of catheter tip cultures in open-heart surgery patients

R. FREEMAN and B. KING

*Department of Microbiology, University of Leeds*

**Freeman, R. and King, B. (1975).** *Thorax*, **30**, 26–30. **Analysis of results of catheter tip cultures in open-heart surgery patients.** A statistical analysis of 628 consecutive catheter tip cultures is presented. All were from patients undergoing open-heart surgery. The previously noted effects of early removal are shown to be significant. The possible effects of stasis, flushing, handling, and place of insertion are discussed.

The unresolved significance of isolations of aerobic sporing bacilli is noted, and a decreasing incidence of postoperative infective endocarditis in the same group of patients is an encouraging sign.

Two previous reports on the isolation of organisms from indwelling intravenous and intra-arterial catheters used in open-heart surgery (Freeman and King, 1972; Freeman, King, and Hambling, 1973) established that these catheters are a potent reservoir of organisms and that early removal of the catheters appears to reduce the incidence of the complication and resistant type of organism.

The earlier series were too small in numbers to allow adequate statistical evaluation of the findings. This report describes the further conclusions which have been reached. As stated previously, the importance of this work lies in the potential contribution of this reservoir of organisms to the incidence of postoperative infective endocarditis.

## PATIENTS AND METHODS

This report is concerned with results on 628 catheter tip cultures from 208 consecutive open-heart surgery patients. The series falls into two parts:

1. Those catheter tips from patients in the earlier part of the series are fewer in number and precede the adoption of the 'early removal policy' described in a previous report (Freeman *et al.*, 1973). These comprise the first 115 catheter tips.

2. The second and larger part of the series is concerned with results obtained after the adoption of the early removal policy and comprises 513 catheter tips.

Note was made of the number of days that the catheter had been in situ, the site of the catheter, and, following culture, the organisms isolated.

Catheters were removed using full sterile precautions, the tip severed using sterile scissors, and the severed tip allowed to fall into a sterile container. Nutrient broth was added to the container upon arrival in the laboratory, and subculture on to solid media followed after 24 hours' incubation of the broth at 37°C. All the organisms isolated were identified by routine methods.

Two further points were considered:

(*a*) the conditions under which the catheter was inserted. The majority of the catheters were inserted in the operating theatre under full theatre precautions as an initial part of the operation. This applies to the right and left atrial (RAC and LAC) and the femoral artery catheter (FAC). The remainder of the catheters are referred to as intravenous catheters (IVC) and were inserted in the intensive care unit. They are examples of catheters inserted on wards, but it is important to note that they are not simple 'drips' of the short cannula type.

(*b*) Nursing staff attending the patients were asked to describe the usages of the catheters in the different sites. They were asked about the frequency with which the various routes were used, the nature of the fluids infused, and the form of monitoring which each catheter provided. It was hoped to assess the degree to which each catheter was manipulated and was thus liable to contamination. The results were as follows:

RAC—Handled a great deal, especially since most drugs are given by this route, often at 2–3 hourly intervals. Blood also infused.

LAC—Closed flush system. Little handling and no infusions.

FAC—Handled a great deal, because it has a tendency to kink. Used as monitoring route for blood gas analysis. No infusions.

IVC—Main route for infusion of crystalloid and certain drugs, for example, isoprenaline. Handled frequently, but less than FAC.



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Drugs are given via a 'three-way tap' system.

It is important to note that each patient received chemoprophylaxis for the operation in the form of eight doses of ampicillin and cloxacillin (1·0 g), given six-hourly by intramuscular injection. The first injection was given 12 hours before operation. In patients known to be hypersensitive to penicillins, cephalothin (1·0 g) was used as an alternative.

The results are given in the Tables. It should be noted that the infection rates have been calculated in duplicate, first, taking into account all isolated organisms and, secondly, excluding the isolations of aerobic sporing bacilli (ASB). ASB are generally regarded as contaminating organisms when isolated from clinical material. It is interesting to note that two recent series have reported the isolation of this type of organism from intravenous catheters and infusion sets (Cox, 1973; Gardner *et al.*, 1974). We have thus left this question open and calculated the results in both ways.

## DISCUSSION

Table I confirms the earlier reports (Freeman and King, 1972; Freeman *et al.*, 1973) in their two assertions. Adoption of the early removal policy has produced a fall in the isolation rate of organisms from the catheter tips from 29·6%, considering all isolates as significant, or 20% if isolates of ASB are ignored, to 12·08% or 5·26% respectively. This difference is statistically significant in both cases ($P<0.001$ in each instance).

The other assertion, that the earlier the catheter is removed the less resistant the type of organism isolated tends to be, is shown in Table II. The differences detailed in Table II between the mean times in situ of those catheters from which organisms were isolated and the sterile catheters are highly significant when analysed statistically ($P<0.00003$ whether the isolations of ASB are included or not).

When the individual catheter sites are considered, the effect of the early removal policy is seen, though not as clearly. In the case of the right atrial catheter (RAC) there is no statistically significant difference in the isolation rates, whether the isolates of ASB are included or omitted ($P>0.05$ in both cases). In the left atrial catheters (LAC), if isolations of ASB are included there is some significant difference ($P<0.05>0.02$) whereas this difference is not found if ASB isolates are omitted ($P>0.05$). No statistically significant difference is found in the isolation rates of the femoral artery catheters (FAC), whether isolations of ASB are ignored or included ($P>0.05$ in each case).

The isolation rates of organisms from the intravenous catheters (IVC), however, show a clearly significant difference ($P<0.001$) when ASB isolates are included, and this difference is still statistically significant when ASB isolates are ignored ($P<0.001$).

We have also considered whether there might be differences between those catheters inserted under operating theatre conditions and those inserted on the intensive care unit. The details of these differences are found in Table III. Analysis of these figures reveals that there is no significant difference in the overall series ($P>0.05$ whether

TABLE I

COMPARISON OF ISOLATION RATES PRIOR TO, AND AFTER, ADOPTION OF AN EARLY REMOVAL POLICY

A. *Prior to early removal policy*

| | R. Atrium | L. Atrium | Femoral Artery | Intravenous Catheters | Total | |
|---|---|---|---|---|---|---|
| No. of catheters | 16 | 12 | 32 | 55 | 115 | 100% |
| No. from which organisms isolated | 1 | 4 | 10 | 19 | 34 | 29·6% |
| No. of isolations excl. ASB | 0 | 0 | 7 | 16 | 23 | 20% |
| % Isolation rates | | | | | | |
| With ASB | 6·25 | 33·3 | 31·25 | 34·5 | | |
| Without ASB | 0 | 0 | 21·8 | 29·1 | | |

B. *After early removal policy*

| | R. Atrium | L. Atrium | Femoral Artery | Intravenous Catheters | Total | |
|---|---|---|---|---|---|---|
| No. of catheters | 114 | 136 | 122 | 141 | 513 | 100% |
| No. from which organisms isolated | 15 | 16 | 20 | 11 | 62 | 12·08% |
| No. of isolations excl. ASB | 3 | 7 | 14 | 3 | 27 | 5·26% |
| % Isolation rates | | | | | | |
| With ASB | 13·15 | 11·8 | 16·34 | 7·8 | | |
| Without ASB | 2·63 | 5·14 | 11·44 | 2·12 | | |

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TABLE II

NATURE OF ORGANISMS ISOLATED FROM TIPS OF CATHETERS

| Organism | Number of Isolates | | | Mean Time in situ of Catheters from which isolated (days) |
|---|---|---|---|---|
| | Total | Before Early Removal | After Early Removal | |
| Aerobic sporing bacilli | 46 | 11 | 35 | 2·1 |
| Micrococci (includes *Staphylococcus albus*) | 21 | 7 | 14 | 2·2 |
| 'Coliform' bacilli | 16 | 7 | 9 | 4·4 |
| Faecal streptococci | 4 | 2 | 2 | 5·0 |
| *Candida albicans* | 7 | 7 | 0 | 6·9 |
| *Pneumococcus*[1,2] | 1 | 0 | 1 | — |
| *Aspergillus nidulans* | 1 | 0 | 1 | — |

[1]Isolated from a catheter in a patient with proven lobar pneumonia.
[2]Serial precipitation tests on this patient's serum showed negative results for aspergillosis, and this organism is regarded as an unusual contaminant.
*Mean time in situ of catheters from which organisms were isolated:*
All organisms 2·93 days
Excluding isolations of ASB 3·72 days
*Mean time in situ of sterile catheters:*
Catheters yielding no organism 1·82 days
Sterile + ASB isolations 1·84 days

TABLE III

COMPARISON OF ISOLATION RATES FROM CATHETERS INSERTED IN OPERATING THEATRE WITH CATHETERS INSERTED ON POSTOPERATIVE WARD

| Catheters inserted in Operating Theatre (RAC+LAC+FAC) | | | Catheters inserted on Postoperative Ward (IVC) | | |
|---|---|---|---|---|---|
| Total | Isolations | Excluding ASB | Total | Isolations | Excluding ASB |
| 432 | 66 (15·28%) | 31 (7·15%) | 196 | 30 (15·25%) | 19 (9·67%) |
| A. *Prior to early removal policy* | | | | | |
| 60 | 15 (25%) | 7 (11·6%) | 55 | 19 (34·5%) | 16 (29·1%) |
| B. *After early removal policy* | | | | | |
| 372 | 51 (13·7%) | 24 (6·43%) | 141 | 11 (7·8%) | 3 (2·1%) |

ASB isolates are ignored or included). Prior to the early removal policy, while there is no statistically significant difference observed when isolates of ASB are included ($P>0·05$), some difference emerges when ASB isolates are ignored ($P<0·05>0·02$). After the adoption of the early removal policy analysis reveals no significant difference whether ASB isolates are included or not ($P>0·05$ in either instance).

Table IV shows that the isolation rate of organisms from catheter tips in the whole series is low for the first three days that the catheters are in situ, especially if ASB isolates are ignored. Thereafter the isolation rate rises to unacceptable levels. We have no direct evidence for the reason, but recent work on the formation of thrombus on prosthetic implants in major veins reveals a similar time interval preceding the formation of the thrombus (Rodman, Wolf, and Mason, 1974). This finding deserves further investigation.

The daily isolation rates for individual catheter sites reveal some possible differences, although the number of samples obtained beyond the fourth day is small. The FAC has a high daily isolation rate, even when ASB isolates are excluded, and the RAC has a lower one. This might be thought predictable for the FAC, since it is frequently handled, but then so is the RAC. Perhaps significantly, the LAC, which is a closed flush system, has a higher daily isolation rate than the RAC. Finally, the IVC has an acceptably low daily isolation rate for the first three days despite being handled frequently. It may be, therefore, that frequent handling may be important but that its effect may be outweighed by the effects of stasis and flushing. Thus catheters which are frequently used for infusion, and which are consequently flushed, may be less susceptible to contamination. These figures are small and no firm conclusions can safely be made.

Another point (in the case of the FAC) is the site, placed as it is near to the perineum. An alternative site might result in a lower isolation rate. We have insufficient data on other arterial sites to make an adequate comparison. Others have reported low isolation rates using the radial artery (Gardner *et al.*, 1974).

In conclusion this series demonstrates the advantages of removing intravenous and intra-arterial catheters at the earliest possible stage. This results in a lower isolation rate and in the isolation of more sensitive organisms. Frequent flushing may be an advantage, and frequent handling may increase the isolation rate. The problem of reducing the isolation rate still further might be helped by further investigation of thrombus formation in the catheter tips.

We have avoided using the term 'infected catheter' since the data presented here do not

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## TABLE IV

RELATIONSHIP BETWEEN LENGTH OF TIME CATHETERS WERE IN SITU AND ISOLATION RATE

A. *Total series, right and left catheters*

| Days in situ | Total Series (all sites) | | Days in situ | Right Atrial Catheters | |
|---|---|---|---|---|---|
| | Isolations | Excluding ASB | | Isolations | Excluding ASB |
| 1 | 27/156 (17·3%) | 9/156 (5·8%) | 1 | 3/43 (6·9%) | 1/43 (2·3%) |
| 2 | 34/246 (13·8%) | 16/246 (6·5%) | 2 | 9/61 (14·7%) | 2/61 (3·3%) |
| 3 | 11/72 (15·3%) | 5/72 (6·9%) | 3 | 3/21 (14·2%) | 0/21 (nil) |
| 4 | 7/26 (26·9%) | 6/26 (23%) | 4 | 0/3 (nil) | 0/3 (nil) |
| 5 | 6/14 (52·0%) | 4/14 (28·6%) | 5 | 1/1 (100%) | 0/1 (nil) |
| 6 | 2/3 (66·6%) | 2/3 (66·6%) | No catheters in this site after day 5 | | |
| 7 | 3/5 (60%) | 3/5 (60%) | | | |
| 8 | 2/2 (100%) | 2/2 (100%) | Days in situ | Left Atrial Catheters | |
| 9 | 1/1 (100%) | 1/1 (100%) | | Isolations | Excluding ASB |
| 10 | 1/1 (100%) | 1/1 (100%) | 1 | 14/111 (12·6%) | 4/111 (3·6%) |
| 15 | 2/2 (100%) | 2/2 (100%) | 2 | 3/31 (9·6%) | 1/31 (3·2%) |
| | | | 3 | 1/3 (33%) | 0/3 (nil) |
| | | | 4, 5, 6 | 2/3 (66·6%) | 2/3 (66·6%) |

B. *Femoral artery and intravenous catheters*

| Days in situ | Intravenous Catheters | | Femoral Artery Catheters | |
|---|---|---|---|---|
| | Isolations | Excluding ASB | Isolations | Excluding ASB |
| 1 | 5/78 (6·4%) | 0/78 (nil) | 4/24 (16·6%) | 3/24 (12·5%) |
| 2 | 9/71 (12·6%) | 5/71 (7%) | 14/71 (19·6%) | 9/71 (12·6%) |
| 3 | 2/22 (9·9%) | 2/22 (9·9%) | 5/38 (13·2%) | 3/38 (7·9⅓) |
| 4 | 3/10 (30%) | 3/10 (30%) | 3/12 (25%) | 2/12 (16·6%) |
| 5 | 2/5 (40%) | 1/5 (20%) | 2/6 (33·3%) | 2/6 (33·3%) |
| 6 | 2/2 (100%) | 2/2 (100%) | nil | nil |
| 7 | 2/3 (66·6%) | 2/3 (66·6%) | 1/2 (50%) | 1/2 (50%) |
| 8 | 2/2 (100%) | 2/2 (100%) | nil | nil |
| 9 | 1/1 (100%) | 1/1 (100%) | nil | nil |
| 10 | 1/1 (100%) | 0/1 (nil) | 1/1 (100%) | 1/1 (100%) |
| 15 | 1/1 (100%) | 1/1 (100%) | | |

prove whether these catheters are infected or whether they are merely colonized by the various organisms. Further work is envisaged to resolve this point. If the result of this suggests that these are true infections, then the prevention of this complication becomes even more important. Particularly important in this context is the possible role of the aerobic sporing bacilli. As stated earlier, these organisms are usually regarded as contaminants, but this series is not the first to report their isolation from intravenous catheters or drip sets in a consistent fashion (Cox, 1973). Pearson (1970), reviewing cases in which these organisms might have been true pathogens, included one case of phlebitis.

More work is urgently needed to assess the significance of these isolations. It had been hoped that comparison of the figures contained in this series, when ASB isolates were included, with the figures obtained when such isolates were ignored might allow some conclusion to be made. However, the Tables show that while the assumption that these organisms are contaminants makes a slight difference to the results, it does not make a difference to any of the statistical analyses. The evidence is thus equivocal.

Final proof of the usefulness of reducing this reservoir of organisms, which is in direct contact with the bloodstream, lies in the demonstration of a progressive fall in the incidence of post-operative infective endocarditis. Other reports on the patients studied on this unit have shown that this is occurring (Ionescu *et al.*, 1972; Ionescu *et al.*, 1974).

### STATISTICAL NOTE

Comparisons of the isolation rates in the various situations were performed using a four-fold table to derive the value of $\chi^2$. The comparison of the mean times in situ was done by a rank number test. We are grateful to Dr. F. C. Odds for his valuable advice on statistical matters.

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Requests for reprints to: Dr. R. Freeman, Department of Microbiology, The University, Leeds.

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