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Acquisition, spread, and control of *Pseudomonas aeruginosa* in a cardiothoracic intensive care unit

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ABSTRACT The isolation rate and spread of infection and colonisation with *Pseudomonas aeruginosa* in a cardiothoracic intensive care unit was studied over two and a half years. The overall acquisition rate was low (2.68%) and was concentrated in the group of patients undergoing prolonged intensive care (over seven days). Although some cross-infection from long-stay to short-stay patients occurred in 1978 and 1979, when cubicle isolation was inadequate, acquisition of *Ps aeruginosa* was confined to the long-stay group when isolation facilities became sufficient. Further study of the long-stay patients disclosed two factors — use of broad-spectrum antibiotics and tracheostomy — significantly associated with acquisition of *Ps aeruginosa*. The possible uses of the results obtained and the particular relevance of a policy of narrow-spectrum chemoprophylaxis for open-heart surgery are discussed.

Introduction

An earlier study from this unit suggested that narrow-spectrum chemoprophylaxis for open-heart surgery might minimise the colonisation and infection with resistant Gram-negative bacilli ("coliforms") often seen in association with chemoprophylaxis using broad-spectrum antibiotics. We decided to evaluate this hypothesis further by examining our experience over two and a half years, during which 1563 patients were admitted and narrow-spectrum chemoprophylaxis was used throughout.

Pseudomonas aeruginosa was selected as the indicator organism to represent all the coliforms because of its clinical importance and discrete identity and the possibility of subdividing isolates by serological typing and thus detecting episodes of cross-infection.

Methods

The 1563 patients passing through the intensive care unit comprise all those undergoing open-heart surgery and one non-surgical cardiac patient. All patients having open-heart and other surgery received chemoprophylaxis with flucloxacillin as previously described[1] unless they were known to be allergic to penicillins, in which case lincomycin was substituted. Included in the total is the group of 52 patients given cephradine prophylaxis and previously reported.[1]

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All postoperative patients yielded a sample of tracheal secretion on the first postoperative day, and thereafter twice weekly if their stay was prolonged. Other patients yielded tracheal secretions on admission and twice weekly thereafter. Since other samples (for instance, urine, wound swabs) were obtained only as needed clinically, tracheal secretions were used as the most reliable specimens on which to compare results.

Details were accordingly compiled of the isolations of *Pseudomonas aeruginosa* over the study period (January 1978–July 1980). Where repeated isolations were made from one patient they were recorded as from one patient. Isolations of *Ps aeruginosa* were identified by standard tests and then further subdivided by a serological scheme.[2] Strains so typed are designated by the somatic (O) antigen and the flagellar (H) antigen—for instance, *Ps aeruginosa*, O1, H2.

Details were kept of the length of stay of each patient in the intensive care unit and the mortality rate (regardless of cause) over the study period. Since we saw early in the study that patients staying in the intensive care unit longer than seven days were a particularly important group, the records of this group were examined in more detail. In all, 89 patients stayed longer than seven days and we traced the notes of 78, the following details being abstracted:

(1) Duration of stay in the intensive care unit. (2) Use of broad-spectrum antibiotics; in addition to the 52 patients given cephradine prophylaxis, several patients were already receiving broad-spectrum drugs at admission, or, commonly, broad-spectrum drugs were added to the narrow-spectrum prophylaxis in patients suffering complications (the term broad-spectrum is defined for this

purpose as referring to a wider spectrum than flucloxacillin has). (3) Presence of renal failure severe enough to warrant dialysis. (4) Use of the intra-aortic balloon pump. (5) Whether the patient had a tracheostomy. (6) Duration of ventilation; patients subsequently having a tracheostomy were excluded from this group. (7) Cerebral complications, including all detectable cerebral insults from minor convulsions to the decerebrate state. (8) Whether the patient died while in the intensive care unit.

One important change in the intensive care unit occurred during the study period in that in 1978 and 1979 the unit comprised a six-bedded open-plan area and two exhaust-ventilation cubicles. Under these circumstances, patients known to be colonised or infected with *Ps aeruginosa* (or any coliform) could not always be removed from the open-plan area into an isolation cubicle. From January 1980 two further cubicles came into use and isolation of such patients was thereafter always possible. The intensive care unit's protocol for the nursing of such patients is simple, emphasising adequate hand disinfection. Barrier nursing is not performed. Finally, whereas one nurse might occasionally attend more than one patient in the open-plan area this does not occur in the cubicles.

Results

Figure 1 shows the throughput of patients in the intensive care unit over the study period. The vast majority of

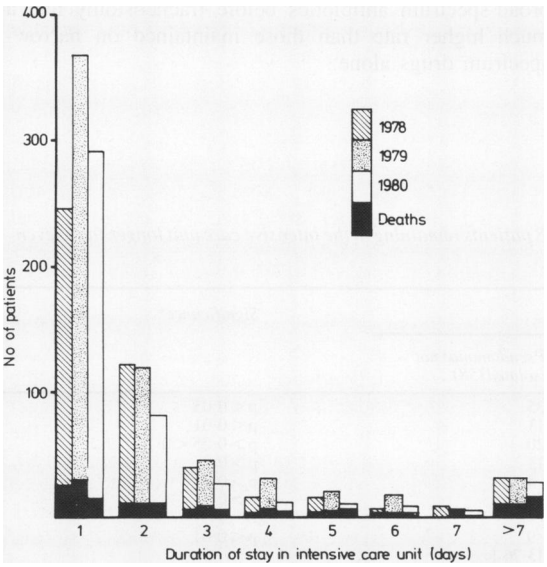

Fig 1 *Throughput of patients in intensive care unit related to duration of stay.*

patients — 1331 of the 1563 (85%) — were discharged from the unit within three days, but a small but important proportion remained much longer. Although recorded merely as "longer than 7 days", the duration in many cases was much longer, the longest being 46 days. These long-stay patients comprise 5·7% of the total.

Isolations of *Ps aeruginosa* were distributed throughout the various short-stay groups as well as the long-stay group in 1978 and 1979, whereas in 1980 isolations were confined to the long-stay group of patients (fig 2). Even in 1978 and 1979 the incidence was highest in the long-stay

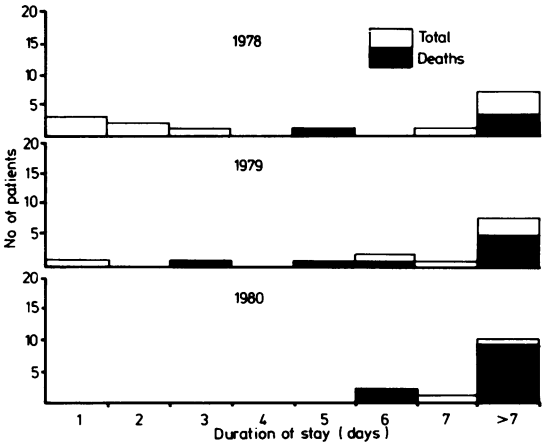

Fig 2 *Isolations of Pseudomonas aeruginosa related to duration of stay (one isolate per patient).*

group. Thus short-stay patients (one to three days in the intensive care unit) were acquiring the organism in 1978 and 1979, but not in 1980. The overall incidence of *Ps aeruginosa* colonisation or infection (as judged by culture of tracheal aspirations) was 2·68%, there being 42 affected patients in the total of 1563. The incidence varied only slightly from year to year, being 3·16% in 1978 (15 patients out of 474), 2·19% in 1979 (14 patients out of 637) and 2·88% in 1980 (13 patients out of 452).

Of the 42 isolates, 26 were typed as *Ps aeruginosa*, O11,H125 and a further 10 as *Ps aeruginosa*, O6,H3. The remaining six isolates were of various types. Clusters of O11,H125 isolates occurred in two periods, January to July 1978 and December 1978 to April 1979. Figure 3 shows the actual duration of stay in the intensive care unit for the affected patients during these two periods. Short-stay patients — for instance, those numbered 3, 5, and 9 — were probably cross-infected from the long-stay patients, such as those numbered 1, 2, and 4, resident throughout the same period. While no isolates of type O11,H125 occurred in 1980, a small cluster of isolates of type O6,H3 occurred from April to July, and the actual duration of stay in the intensive care unit of the patients affected is seen in figure 4. No short-stay patients were affected, the shortest duration of stay of any such patient being six days (No 3). Thus if cross-infection occurred it was restricted to the long-stay patients.

Attempts were made to associate the various factors examined in the long-stay group with the acquisition of *Ps*

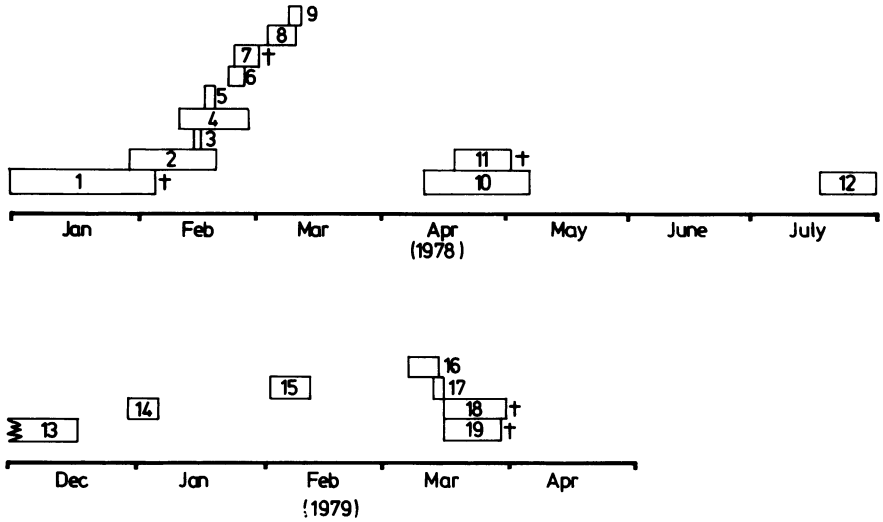

Fig 3 *Periods of stay in intensive care unit of patients affected in clusters of Pseudomonas aeruginosa, O11,H125 isolations († = death in intensive care unit).*

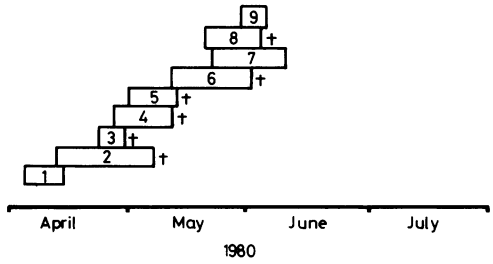

Fig 4 *Periods of stay in intensive care unit of patients affected in cluster of Pseudomonas aeruginosa, O6,H3 isolations († = death in intensive care unit).*

aeruginosa (table). Only two of the factors examined show a significant association — the use of broad-spectrum antibiotics and the performance of tracheostomy. Figure 5 shows that the acquisition of *Ps aeruginosa* after tracheostomy occurred within a few days of the operation, and that those patients receiving broad-spectrum antibiotics before tracheostomy had a much higher rate than those maintained on narrow-spectrum drugs alone.

Associations of various factors with acquisition of Ps aeruginosa in 78 patients remaining in the intensive care unit longer than seven days

Factor	*No of patients from whom*		*Significance**
	Pseudomonas isolated (20)	*Pseudomonas not isolated (58)*	
Broad-spectrum antibiotics	18	35	$p < 0.05$
Tracheostomy	12	13	$p < 0.01$
Death in unit	12	20	$p > 0.05 < 0.1$
Cerebral insult	7	13	$p > 0.2$
Dialysis	2	4	$p > 0.5$
Intra-aortic balloon pump	7	18	$p > 0.5$
Broad-spectrum antibiotics plus tracheostomy	11	9	$p < 0.01$
Duration of stay in unit (mean)	14·45 days	13·76 days	
Duration of intubation (mean)	11·25 days	10·73 days	
Acquisition rate of *Ps aeruginosa* related to antibiotic use:			
Antibiotic spectrum	*No of patients*	*No acquiring organism*	*Significance*
Narrow throughout	25	2	$p < 0.01$
Broad	53	18	

*Statistical comparisons by χ^2 analysis with Yates's correction.

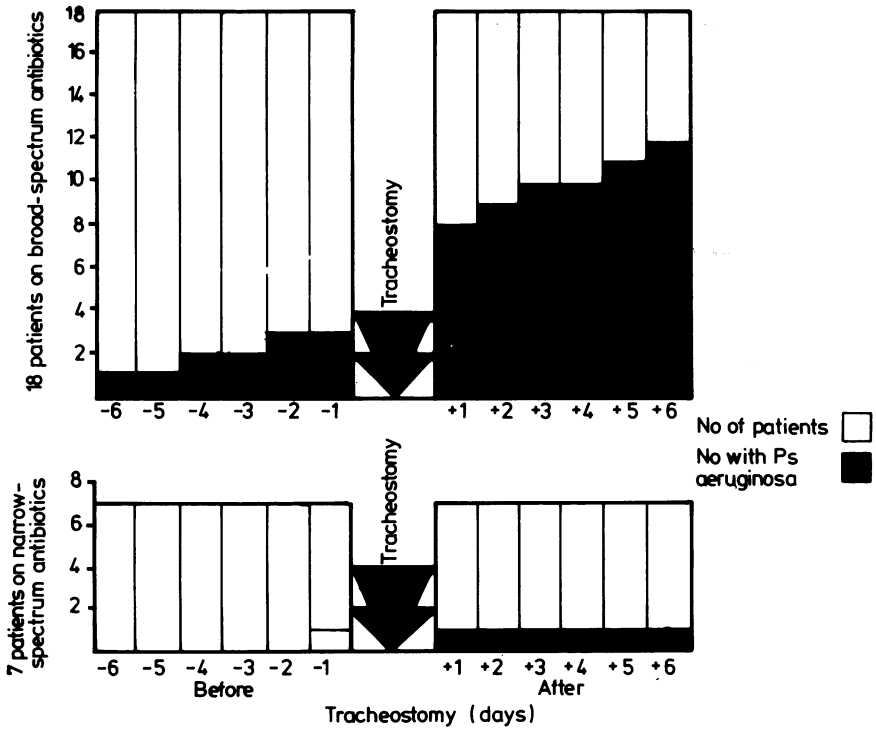

Fig 5 *Appearance of Pseudomonas aeruginosa in tracheal secretion related to time of tracheostomy.*

Discussion

The dedication of an intensive care unit to a relatively "clean" surgical specialty is acknowledged to be advantageous in preventing the introduction of resistant bacteria, particularly the coliform variety. Even "pure-specialty" intensive care units, however, may suffer badly with endemic and epidemic infection and colonisation due to resistant Gram-negative bacilli, and in some instances this problem has been directly attributed to the indiscriminant use of broad-spectrum antibiotics,[3] often given prophylactically. The previous study from this unit suggested that if chemoprophylaxis for open-heart surgery was deemed necessary (and its necessity is by no means beyond dispute), then narrow-spectrum chemoprophylaxis with flucloxacillin offered an acceptably low incidence of early prosthetic valve endocarditis while minimising the short-term problems due to "coliform" colonisation and infection in the intensive care unit at the immediate postoperative stage. This extended study has underlined that conclusion by showing that one index of coliform infection and colonisation — that is, the presence of *Ps aeruginosa* in tracheal secretions — has remained gratifyingly low over a prolonged period when narrow-spectrum prophylaxis has been the standard method. Indeed, this study has further shown that even the low incidence of *Ps aeruginosa* detected might be reduced still more, since we found that the problem emanated from those patients remaining in the intensive care unit longer than normal. Once adequate cross-infection control was established, no patient remaining in the intensive care unit less than six days (that is, over 90%) acquired *Ps aeruginosa*. This was achieved by simple physical isolation and adequate hand disinfection, a policy previously shown to control cross-infection with this type of organism.[4]

This study also offers hope that the acquisition of *Ps aeruginosa* (and similar organisms) can be prevented or delayed even in the long-stay patients, since we found that the addition of broad-spectrum antibiotics to the narrow-spectrum prophylaxis was significantly associated with acquisition of the organism. This finding further emphasises the thesis that narrow-spectrum prophylaxis is to be preferred. This is not to advocate that long-stay patients should not receive broad-spectrum antibiotics when sound reasons for their prescription exist, but administration of these drugs speculatively in such patients remains a common finding. The use of broad-spectrum antibiotics could probably be reduced in this group of patients, acquisition of *Ps aeruginosa* thus being diminished without prejudice to clinical care.

The association of *Ps aeruginosa* with tracheostomy in the long-stay group also merits consideration. In long-stay patients tracheostomy may be performed to facilitate

management and to pre-empt the most serious complication of prolonged intubation — that is, tracheal stenosis. In a recent prospective survey in which tracheostomy and prolonged intubation were compared, Stauffer *et al* concluded that the non-infective complications were similar in the two groups if modern endotracheal intubation techniques were carefully applied.[5] The present study has shown that prolonged intubation as distinct from tracheostomy does not appear to be associated with acquisition of *Ps aeruginosa*. Thus there may be grounds for reducing the incidence of tracheostomy in the long-stay patients (in this series it was 32%), with a concomitant reduction in the incidence of *Ps aeruginosa*. A final point, exemplified in figure 5, is that patients about to undergo tracheostomy are less likely to acquire *Ps aeruginosa* if they are maintained on narrow-spectrum antibiotics.

In conclusion, the experience of this unit has clearly been that narrow-spectrum chemoprophylaxis for open-heart surgery, combined with good cross-infection control, has served well in minimising the problems associated with resistant Gram-negative organisms in intensive care units. The incidence of early prosthetic valve endocarditis remains acceptably low with narrow-spectrum prophylaxis, being 0·38% of all bypass operations (six patients out of the 1562 reported here) or 0·56% of all valve insertions (four patients out of 708).

We thank the nursing staff of ward 26 (the cardiothoracic intensive care unit), and our medical and surgical colleagues in the regional cardiothoracic centre at the Freeman Hospital for their interest and help.

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