

## Suction apparatus and hospital infection due to multiply-resistant *Klebsiella aerogenes*

J. I. Blenkarn and Victoria M. Hughes

*Department of Bacteriology, Royal Postgraduate Medical School,  
Hammersmith Hospital, Du Cane Road, London W12 0HS*

**Summary:** Following an outbreak of cross-infection with multiply-resistant *Klebsiella aerogenes* epidemiological studies demonstrated the association of the use of suction apparatus with the distribution of positive cases. Eighty per cent of 66 cases had been exposed to this equipment. Environmental and clinical isolates were compared with strains of *klebsiella* recovered from suction apparatus. Colonial morphology, klebecin sensitivity and production, antibiotic resistance pattern and determination of plasmid molecular weight and incompatibility were used to discriminate between strains. A disinfection policy has been introduced to cope with the use of suction apparatus.

### Introduction

A wide variety of hospital equipment has been incriminated in hospital infection, the number of reports of device-related sepsis having risen dramatically since 1965 (Stamm, 1978). Most frequently incriminated have been humidifiers (Smith and Massanari, 1977; Redding and McWalter, 1980), ventilation/anaesthetic equipment and equipment for intravenous infusion therapy (Stamm, 1978). With the increasing use of complex equipment for patient care, active consideration must be given to the rôle of such equipment in hospital cross-infection. This is particularly the case for equipment that is infrequently used and when circumstances demand the sharing of equipment between a number of different wards.

Following an outbreak of infection with strains of multiply-resistant *klebsiella* occurring over a 10 month period, clinical, laboratory and epidemiological studies were performed which incriminated hospital suction apparatus as a major source. To our knowledge no previous studies have demonstrated any rôle of suction apparatus in hospital cross-infection. The results of our investigations are described together with recommendations for the use and care of such apparatuses.

### Methods

#### *The outbreak*

During the period December 1979 to September 1980 a number of incidents of apparent cross-infection with multiply-resistant *K. aerogenes* K21 occurred, involving a total of 66 patients. Of these 66, 38 (58 per cent) were considered to be clinically infected with *K. aerogenes*. The majority of these isolations were from wound swabs, sputum and blood cultures with fewer from urine and peritoneal dialysis fluids. Of the remaining 28 (42 per cent) patients, isolates of *K. aerogenes* were mainly from skin, faeces and urine and were considered to play no pathogenic rôle.

*Bacteria*

The bacteria included in this study were isolated from inpatients and environmental samples sent to the routine and research laboratories in the Hammersmith Hospital between December 1979 and September 1980. Isolates were identified by the methods of Cowan (1975) and sensitivity to antibiotics tested by disc diffusion using Stokes' (1975) method.

Serotyping of the capsular antigens by counter-current immunoelectrophoresis was undertaken by Dr P. R. Mortimer at the Public Health Laboratory, Coventry. Klebecin typing and examination of plasmid DNA and plasmid transfer was as previously described (Hughes, Henderson and Datta, 1981). Tests for klebecin production were as described by Edmondson and Cooke (1979) using their 16 indicator strains and tests of plasmid incompatibility as described by Datta (1979).

*Environmental studies*

Environmental studies conducted during the early part of this outbreak (Hughes *et al.*, 1981) involved extensive screening of ward dust, sluices and vessels, etc. From 190 such samples, only two isolates of resistant klebsiella were obtained, one from a jar of hand cream beside a ward wash basin and one other from a measuring jug used for urine in a ward sluice room.

Additional environmental studies have now been performed confined to two surgical wards particularly affected with a number of apparently separate episodes of klebsiella cross-infection. These later studies included examination of sluices and drains, hand basins, disinfectant solutions and a wide range of ward equipment including suction apparatus, humidifiers, ventilators, thermometers, etc. Where necessary, equipment was dismantled prior to laboratory examination so that internal surfaces could be investigated. Humidifiers, ventilators and suction apparatus were also examined *in situ*.

The distribution of resistant klebsiella isolates was also re-examined. This included evaluation of patient movement between wards with particular regard to the type of ward and the equipment used in each area.

**Results**

The environmental studies performed during the latter part of this outbreak revealed the presence of resistant klebsiella in five out of seven suction pumps. These isolates together with all patient isolates are shown in Tables I and II.

Table I. *Isolates of Klebsiella aerogenes K21, klebecin 11 sensitive and their sources*

Group	Number of isolates	Date of isolation	Source (n)
Ia	49	December 1979 to May 1980	Patients (54) Environment (2)
b	3		
c	4		
IIa	1	March 1981	Pump
b	2	March 1981	Pumps
III	8	February-March 1981	Patients (5) Pumps (3)

Table II. *Properties of Klebsiella aerogenes (K21, klebecin 11 sensitive) studied*

Group	Colony morphology	Klebecin production	Antibiotic resistance pattern	mol. wt. (Md) of plasmid
Ia b c	Smooth	+	ApSmTcCmKmSuGmTmTpHgTe	{ 70 110 110 85 110
110 Md plasmid encodes all the resistances, and is transmissible to <i>Escherichia coli</i> K12 (Hughes <i>et al.</i> , 1981)				
IIa	Smooth	+	ApCmGmTmHg	70 85
b	Smooth	+	ApCmGmTmHg	85
85 Md plasmid encodes ApGmTmHg resistances, and belongs to the same incompatibility group as 110 Md plasmid of group I strains				
III	Rough	—	ApSmTcKmSuGmTmTpTe	120
Resistances <i>not</i> transmissible to <i>Esch. coli</i> K12				

Abbreviations: Ap, ampicillin; Sm, streptomycin; Tc, tetracycline; Cm, chloramphenicol; Km, kanamycin; Su, sulphonamide; Gm, gentamicin; Tm, tobramycin; Tp, trimethoprim; Hg, mercuric chloride; Te, potassium tellurite; mol. wt. (Md), molecular weights in megadaltons.

All strains were gentamicin-resistant *K. aerogenes* of serotype K21 and sensitive to klebecin 11. They were subdivided into three groups by colonial morphology, klebecin production, antibiotic resistance pattern and by plasmid analysis. Eight strains (group III) were of rough colonial morphology, did not produce klebecin and their antibiotic resistance could not be transferred to *Escherichia coli* K12. These strains could, therefore, be distinguished from the predominant epidemic strain (group I). Of these group III strains, three were recovered from suction pumps and five from clinical isolates during a four week period.

The suction pumps examined yielded, in addition to the three rough strains, three smooth strains (group II). As no change in colonial morphology was observed after several cycles of replating from single colonies, these smooth strains were investigated further. As with the main epidemic strains (group I) they produced klebecin active on 14 of the set of 16 klebecin indicators. Laboratory examination of the stability of the resistances of the major epidemic strain (group I) in the absence of antibiotic selection showed that the 110 megadalton (Md) plasmid was unstable and could be lost. It also gave rise to a plasmid variant of 85 Md encoding only ampicillin, gentamicin, tobramycin and mercuric chloride resistances (Bradley *et al.*, 1982). In the klebsiella host a second chloramphenicol resistance, additional to that determined by the 110 Md plasmid, is known to be chromosomal (V. M. Hughes, unpublished results). By breakdown of the 110 Md plasmid to its 85 Md variant, strains IIa and IIb could have arisen from Ia and Ib respectively. Classification of the 110, 85 and 120 Md plasmids by incompatibility (Datta, 1979) showed that the 110 and 85 Md plasmids are related to one another but not to the 120 Md plasmid in group III strains.

Of the suction pumps examined, resistant klebsiella were recovered in large numbers from overflow valves, oil chamber and reservoirs, exhaust filters and exhaust air. In two instances pumps were examined whilst in use and the exhaust air was shown, by impaction on MacConkey plates, to be heavily contaminated with group II and group III strains whilst being used for patients who were neither colonized nor infected with resistant klebsiella. Furthermore, a third pump was found to be contaminated with a group II strain whilst being used on a patient infected with the group I strain of klebsiella.

*Pseudomonas aeruginosa*, again in large numbers, was also recovered from various sites within the suction apparatus. With a high incidence of *Ps. aeruginosa* sepsis in this surgical unit and with no other apparent reservoir it is tempting to believe that this type of suction apparatus constitutes a significant source. Unlike the situation with resistant klebsiella however, epidemiological evidence is not at present available.

### *Epidemiology*

The suction apparatus incriminated as a major source in this hospital-wide outbreak was the Robert's type suction pump manufactured by the Genito-Urinary Manufacturing Co. Ltd. These pumps are used almost exclusively for suction drainage of wound cavities and are therefore mainly restricted to surgical wards.

Individual pumps were frequently moved from one surgical ward to another as required.

Of the 66 patients recognized in this outbreak, 42 (64 per cent) were surgical patients. Twenty cases occurred amongst surgical patients during the first eight weeks of the outbreak, prior to the recovery of resistant klebsiella from patients on medical wards. Moreover, the first two cases recognized on medical wards had both been nursed in the intensive care unit (ICU). This ICU is used primarily for post-surgical patients and is, therefore, the site of maximum use of Robert's suction apparatus. Subsequently, a further nine out of 24 medical patients with resistant klebsiella were identified as having been nursed in the ICU. Thus of 66 patients affected, 53 (80 per cent) had been nursed on wards where Robert's suction apparatus was in use, whilst only 13 (20 per cent) had not.

### Discussion

The significance of the isolation of potential pathogens from hospital suction apparatus has been questioned (Roncoroni, Casewell and Phillips, 1980). During the course of this hospital-wide outbreak of cross-infection with resistant klebsiella it became clear that contamination of Robert's suction apparatus, in particular the heavy contamination of exhaust air, could be a major factor in the dissemination of organisms throughout the hospital.

Formalin vapour disinfection of Matburn suction pumps was suggested by Roncoroni *et al.* (1980). The provision of such disinfection facilities involves considerable capital expenditure. The penetration of formalin vapour to the oil reservoir of such apparatus has not been studied and therefore the efficiency of this method of decontamination is questioned even though the Matburn pumps were functioning throughout the disinfection cycle thus allowing formalin vapour to pass through the oil pump. Our studies with Robert's pumps demonstrated viable bacteria in an oil/water emulsion within the oil reservoir. It is conceivable therefore that such bacteria may be protected from formalin vapour. Our policy for the use of any suction apparatus in this hospital now includes the addition of 30 ml of phenolic disinfectant (undiluted 'Clearsol' or 'Stericol') to the collecting flask. This presents no risk to the patient since the non-return valve and suction system makes reflux impossible. Furthermore 0.5 per cent (v/v) mono-chloro-ortho-phenyl-phenol (MCOPP) is added to the oil in the reservoir. This compound has the biocidal properties of phenol yet is miscible with, and does not affect the lubricating properties of, the oil. Moreover, it does not react adversely with the various metal components of the oil pump and having a much lower vapour pressure than phenol presents a lesser toxicological hazard. No bacterial growth was detected from samples of the oil/MCOPP taken at three and six months of constant use. In-use studies suggest that replacement of oil plus MCOPP at six month intervals gives adequate protection.

It must be emphasized that the contaminated Robert's suction apparatus, incriminated as a major source in this outbreak, was of the older type of equipment no longer commercially available. Dissemination of bacteria was due in particular

to the absence of an air filter between the collecting flask and oil pump allowing passage of aerosol from the flask to the oil reservoir. On this older type of apparatus the outlet air was filtered, but a serious defect was observed—oil vapour contaminating the exhaust air caused collapse of the cotton wool exhaust filter with subsequent loss of filter efficiency.

We conclude that contamination of old type Robert's suction apparatus was a major factor in the outbreak of cross-infection with resistant klebsiella reported here. It is likely that such old type equipment is still in use in many hospitals and that this problem is not an isolated incident. With the incorporation of an adequate fibre air filter between collecting flask and oil pump on currently available Robert's suction apparatus the hazard of contamination is significantly reduced. We strongly recommend, however, the addition of phenolic disinfectant to the collecting flask and of MCOPP to the oil reservoir as additional safeguard particularly when formalin vapour disinfection facilities are not available.

We should like to thank Professor N. Datta for her guidance and advice, and the Medical Research Council for support.

### References

- Bradley, D. E., Hughes, V. M., Richards, H. & Datta, N. (in press). R plasmids of a new incompatibility group determine constitutive production of H pili. *Plasmid*.
- Cowan, S. T. (1975). *Manual for the Identification of Medical Bacteria*, 2nd edn. Cambridge University Press, Cambridge.
- Datta, N. (1979). Plasmid classification: incompatibility grouping. In *Plasmids of Medical, Environmental and Commercial Importance*, pp. 3–12. Elsevier Biomedical Press, North Holland.
- Edmondson, A. S. & Cooke, E. M. (1979). The development and assessment of a bacteriocin typing method for *Klebsiella*. *Journal of Hygiene, Cambridge* **82**, 207–223.
- Hughes, V. M., Henderson, W. G. & Datta, N. (1981). Discriminating between multiply-resistant klebsiella strains during a hospital outbreak: use of klebecin-typing and a screening test for plasmids. *Journal of Hospital Infection* **2**, 45–54.
- Redding, P. J. & McWalter, P. W. (1980). *Pseudomonas fluorescens* due to contaminated humidifier water. *British Medical Journal* **281**, 275.
- Roncoroni, A. J., Casewell, M. W. & Phillips, I. (1980). The disinfection of clinically contaminated Matburn suction pumps and baby incubators in an 'Aseptor' formalin cabinet. *Journal of Hospital Infection* **1**, 251–259.
- Smith, P. W. & Massanari, R. M. (1977). Room humidifiers as the source of *Acinetobacter* infections. *Journal of American Medical Association* **237**, 795–797.
- Stamm, W. E. (1978). Infections related to medical devices. *Annals of Internal Medicine* **89**, 764–769.
- Stokes, E. J. (1975). *Clinical Bacteriology*, 4th edn. Edward Arnold, London.