Hands as route of transmission for Klebsiella species

MARK CASEWELL, IAN PHILLIPS

British Medical Journal, 1977, **2**, 1315-1317

Summary

Seventeen per cent of the staff of an intensive care ward were found to have Klebsiella spp contaminating their hands, and these strains could be related to serotypes infecting or colonising patients in the ward on the same day. We identified some simple ward procedures that resulted in contamination of nurses' hands with 100-1000 klebsiellae per hand. Klebsiellae survived on artificially inoculated hands for up to 150 minutes.

Handwashing with chlorhexidine hand cleanser reliably gave 98-100% reduction in hand counts, and the introduction of routine handwashing by staff before moving from one patient to the next was associated with a significant and sustained reduction in the number of patients colonised or infected with Klebsiella spp. Staff clothing was occasionally contaminated, but ward air and dust rarely contained klebsiellae.

Introduction

Results from this laboratory[1] and elsewhere[2] suggest that endemic klebsiella infection cannot be wholly explained by a common source or autoinfection from the patient's own bowel flora, and we have found it necessary to postulate cross-infection in addition. Few, if any, published studies have used typing of this genus to investigate routes of transmission for *Klebsiella* species in a single ward or limited area of a hospital.

There is limited evidence that klebsiellae can be recovered from the hands of both staff and patients in certain wards,[3] and apparently no evidence relating the klebsiella serotypes isolated from hands to the types found in patients. Nor is it clear which ward procedures contaminate staff hands, how long the organisms survive on dry hands, or what washing procedures are required to remove klebsiellae from contaminated hands.

We report the results of our investigation of the routes of transmission of *Klebsiella* spp in an intensive care unit in which we had already established the epidemiological patterns of patient isolates,[1] and explored the possible sources of klebsiellae.[1] The availability of a technique for typing of *Klebsiella* spp[5 6] enabled us to assess the relevance of the possible routes of transmission more accurately.

Methods

The intensive care unit has been described elsewhere in some detail.[7] Exceptionally thorough routine bacteriological monitoring enabled us to identify patients colonised or infected with *Klebsiella* spp. In April 1974 the importance of handwashing before moving from one patient to the next was emphasised to doctors and nurses, and handwashing with chlorhexidine (4% w/v) hand cleanser was introduced as a routine procedure.

Sampling for routes of transmission—Handwashing samples were taken by putting the hand into a sterile extra-large "Dispos-a-glove" (Ethicon Ltd), and pouring 50 ml of sterile quarter-strength Ringer's solution into the glove. The gloved fingers were then rubbed together for 30 s, and the washings transported in a sterile screw-cap glass jar. Air was sampled during times of moderate nursing activity by means of a slit sampler (Bacteria sampler No 2, Casella and Co Ltd); 150-litre samples were passed over the surface of a MacConkey agar plate. Dust particles were cultured on MacConkey agar settle-plates exposed for 4 to 6 hours around the beds of patients known to be colonised with klebsiellae. Staff uniforms were pressed on the surface of nutrient agar plates with a sterile metal former.

Isolation and typing of klebsiellae—Fifty ml of double-strength MacConkey broth was added to each handwashing, and semiquantative klebsiella counts made in accordance with the method of Salzman *et al.*[3] Donovan's klebsiella medium[8] was used to screen all colonies with coliform morphology, and further identification methods were based upon those of Cowan and Steel.[9] All klebsiella isolates were capsular-typed by the method previously described in this laboratory.[5 6]

Survival of klebsiellae on dry hands—The palmar surfaces of both hands of volunteers were dipped into a fresh culture of klebsiella serotype K47 or K21 (the commonest endemic strains in this ward), which had been diluted in physiological saline pH 7·0 to give about 1000 organisms per ml. The hands were then allowed to dry for 5 minutes, and a washing was taken from the right hand to give an estimate of the number of klebsiellae recoverable in washings at the time of inoculation. The left hand was sampled after the chosen time interval had elapsed. The experiment was repeated with increasing time intervals between inoculation and sampling of the left hand.

Removal of klebsiellae by various handwashing procedures—Both hands were inoculated as above with klebsiella types K47, K21, K19, K24, or K55. The right hand was then sampled to obtain a quantitative estimate of the inoculum. Four different handwashing procedures were used. (1) Rubbing the hands together under warm running tap water (approximate temperature 40-50°C) for 20 s; (2) rinsing in warm tap water for 5 s, washing with non-medicated soap for 15 s, and rinsing for 5 s; (3) as (2), but with medicated hospital soap containing triclosan (Derl, Weddel Pharmaceuticals; Irgasan DP 300, Ciba-Geigy); (4) as (2), but with liquid chlorhexidine (4% w/v) hand cleanser. After washing, the left hand was sampled to estimate the recoverable klebsiella count.

Results

In a preliminary survey 17% of handwashings from 28 staff taken on different days yielded *Klebsiella* spp. On four ocasions the klebsiella serotypes were identical with those colonising or infecting patients in the ward on the day of sampling.

In 47 observations klebsiellae were found to have been transmitted to nurses' hands on 17 occasions after varying nursing procedures (table I). All seven patients were found to have klebsiellae in the nasopharynx and on the skin (often hands and groin), as well as in their faeces. The serotypes (K47 and K10) colonising patient A's hands were transferred to the nurse's hands, but type 21, found in the patient's stool, was not. In all patients, except patient E, klebsiellae from the patients' hands could be transferred to the nurse undertaking simple, "clean" procedures.

SURVIVAL OF KLEBSIELLAE ON HANDS

Table II shows the length of survival of types 21 and 47 after inoculation on volunteers' hands. Type 21 survived drying for up to 75 minutes and could be recovered in somewhat reduced numbers in five out of five instances in which an interval of between 20 and 45 minutes had elapsed between inoculation and sampling. Type 47 could also be recovered in 11 out of 12 instances 20-150 minutes after inoculation. Usually there was approximately a tenfold decrease in viable klebsiella counts recoverable from handwashings.

Table III summarises the percentage reductions in estimated viable counts of handwashings taken after rinsing and after washing with

Department of Microbiology, St Thomas's Hospital Medical School, London SE1 7EH

MARK CASEWELL, BSC, MRCPATH, senior lecturer in microbiology
IAN PHILLIPS, MD, MRCPATH, professor of microbiology

TABLE I—*Transfer of klebsiellae to nurses' hands*

Patient	Nursing activity	Klebsiella types colonising patient	Klebsiellae recovered from nurses' hands	
			Type	No per hand
A	Lifting patient	21, 47, 10	47, 10	$10^{2\cdot3}$
B	General nursing	21	21	1–10
	*Physiotherapy	21	21, 28	$10^{1\cdot2}$
	*Taking blood pressure and pulse	21	21	$10^{2\cdot3}$
	*Washing patient	21	21	$10^{1\cdot2}$
	*Oral temperature	21	21	$10^{2\cdot3}$
	*Washing patient	21	24, 28	$10^{1\cdot2}$
C	*Radial pulse	21	21	$10^{2\cdot3}$
	*Touching shoulder	21	21	7×10^{3}
	*Touching groin	21	21	$10^{2\cdot3}$
D	*Washing patient	21, 45, 9	21, 45	$10^{2\cdot3}$
E	General nursing	15	15	$10^{2\cdot3}$
	*Extubation	15	15	$10^{2\cdot3}$
	Touching groin	15	15, 19	10^{3}
F	*Touching hand	55, 47	55	$10^{1\cdot2}$
	*Touching tracheostomy	55, 47	55	10^{4}
G	Touching hand	NT	NT	$10^{1\cdot2}$

*Control handwashings taken before start of procedure: none yielded klebsiellae.
NT = Non typable.

TABLE II—*Recovery of klebsiellae (types 21 and 47) from dry, artificially inoculated hands*

Time after inoculation (min)	No of experiments		
	Total	Klebsiellae recovered	Klebsiellae recovered with only tenfold or less reduction in count per hand
20	2	2	2
30	5	5	4
45	2	2	2
60	5	3	3
75	3	3	3
90	3		
105	1	1	1
120	1	1	1
135	1	1	
150	1	1	1

TABLE III—*Reduction in viable klebsiella counts on artificially inoculated hands after various washing procedures. Absence of result indicates no appreciable reduction*

Washing procedure	No of experiments		
	Total	98% Reduction	100% Reduction
Warm water	8		
Chlorhexidine hand cleanser	23	19	14
Non-medicated soap	4	2	1
Medicated soap	13	10	6

chlorhexidine hand cleanser, plain soap, and medicated soap. On each of four occasions washing with plain soap failed to eliminate all the inoculated klebsiellae, and the percentage reductions in viable counts were similar to those obtained by simply rinsing the hand in water. On 10 out of 13 occasions the use of medicated soap resulted in the removal of at least 98% of the inoculated organisms.

Chlorhexidine hand cleanser reduced viable counts most reliably, giving at least 98% reduction on 19 out of 23 occasions and a 100% reduction on 14 occasions. Even when the hand was contaminated with more than 100 000 klebsiellae, washing with chlorhexidine reduced the count by 99·3-99·9% on five occasions.

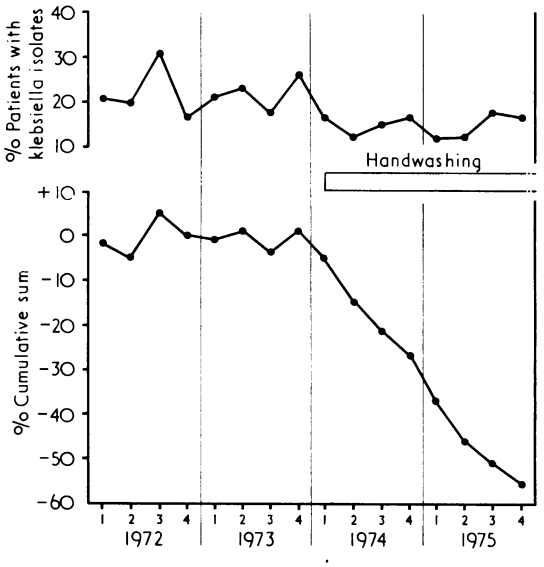
OTHER POSSIBLE ROUTES OF TRANSMISSION

Klebsiellae were not found once in 3100 litres of sampled air. Of 47 settle-plates, seven yielded klebsiellae. Six colonies of klebsiella serotype K21 were found on three plates around the bed of a patient known to have type 21 in her sputum, and who was receiving treatment with a Bird respirator. Capsular types 47, 55, and 31 were isolated as a few single colonies on four plates placed near a patient known to have types 47 and 55 in his mouth, nose, and faeces.

Five out of 30 impression plates yielded 1-12 colonies of klebsiellae. Serotyping showed that there were six capsular types, three of which could be related to contact between that member of staff and a patient colonised with the same serotype.

COLONISATION AND INFECTION OF PATIENTS BEFORE AND AFTER INCREASED STAFF HANDWASHING

The figure shows the quarterly percentage of patients becoming colonised or infected with klebsiellae between 1972 and 1975, and the cumulative sum of these percentages. There was an annual rate of colonisation or infection for 1972 and 1973 of 22·0% and 22·6%



Quarterly percentages of patients colonised or infected with klebsiellae 1972-5, and change in cumulative sum of percentages associated with staff handwashing.

respectively, but the percentage of patients acquiring klebsiellae declined between 1973 and 1974 from 22·6% to 15·5%—a reduction that seemed to coincide with the introduction of handwashing in the first quarter of 1974. The proportion of colonised or infected patients for two years before the introduction of handwashing was significantly greater than that for the subsequent two years ($P < 0.001$).

Discussion

Our results provide little evidence that air or dust-borne particles are a route of transmission for klebsiellae on this ward. Similarly, the results of the limited examination of staff uniforms suggest that this is not a major route of transmission, although staff clothing was occasionally contaminated with strains related to infected patients. Gowns or aprons should therefore be disposable, or at least restricted to individual patients.

Although klebsiellae may be found on the hands of staff or patients,[3] our results show that the capsular types contaminating hands do relate to the types colonising or infecting patients in the ward. Furthermore, our results show that only slight contact with the patient's skin may be required for the transfer of 100-1000 viable klebsiellae to the nurses' hands. These nurses considered that they had "clean" hands, and would not normally have washed before attending another patient, unless they were about to undertake an aseptic technique.

There seems to be little published work on the survival of klebsiellae on dry hands. Our results show clearly that with an inoculum similar to that found on contaminated hands of ward staff, endemic strains of klebsiellae may survive up to 150 minutes. Such unexpected contamination of hands and prolonged survival of organisms provides a highly plausible route of transmission both in this ward and probably elsewhere. The

handwashing studies show that chlorhexidine hand cleanser is an easy, practical method of removing such organisms from the hands of staff, and these findings agree with those of Lowbury *et al*[10] who studied alcoholic solutions for the preoperative disinfection of surgeon's hands.

The reduction in klebsiella colonisation or infection of newly-admitted patients that coincided with increased staff handwashing, and which was sustained over two-years, provides perhaps the most convincing evidence that hands are a major, but correctable, route of transmission for *Klebsiella* spp.

Transmission of klebsiellae from hands explains several epidemiological features of klebsiella infection we have previously observed in this ward. It explains how the serotypes contaminating food may be transmitted from the bowel of a colonised patient to clinical lesions in others, and why food types relate to patient-isolates on this ward as a whole while individual patients do not always acquire the strain that they have themselves ingested. Furthermore, such a route of transmission would contribute, via cross-infection, to the "clusters" of clinical infection and colonisation with the same serotype that we observed between 1969 and 1973. Hands may also be an important route of transmission in types of hospital-acquired klebsiella infection of obscure epidemiology, such as the spread of gentamicin-resistant klebsiella strains.

This study was supported by a grant from the Medical Research Council. We thank Miss U Lakhani for technical assistance.

Requests for reprints should be sent to Dr M W Casewell.

References

1 Casewell, M W, and Phillips, I. In press.
2 Selden, R, *et al*, *Annals of Internal Medicine*, 1971, **74,** 657.
3 Salzman, T C, Clark, J J, and Klemm, L, *Antimicrobial Agents and Chemotherapy—1967*. 1968, p 97.
4 Casewell, M W, and Phillips, I. In press.
5 Casewell, M W, *Journal of Clinical Pathology*, 1972, **25,** 734.
6 Casewell, M W, *Journal of Clinical Pathology*, 1975, **28,** 33.
7 Bell, J A, *et al*, *British Medical Journal*, 1974, **2,** 483.
8 Donovan, T J, *Journal of Medical Laboratory Technology*, 1966, **23,** 194.
9 Cowan, S T, and Steel, K J, *Manual for the Identification of Medical Bacteria*, 1st edn. Cambridge, The University Press, 1965.
10 Lowbury, E J L, Lilly, H A, and Ayliffe, G A J, *British Medical Journal*, 1974, **4,** 369.

(*Accepted 9 September 1977*)

Effect of oestrogen on the sleep, mood, and anxiety of menopausal women

JOAN THOMSON, IAN OSWALD

British Medical Journal, 1977, **2,** 1317-1319

Summary

A double-blind controlled study of the effect of piperazine oestrone sulphate on sleep, depression, anxiety, and hot flushes was performed in 34 perimenopausal women. Half of the patients were given six weeks' placebo followed by eight weeks' oestrogen, and half remained on placebo throughout. Sleep was recorded electrophysiologically every week, and mood and anxiety were rated daily by means of visual analogue scales. Hot flushes were counted daily. Observer rating scales of anxiety and depression were completed at intervals.

During the first month of active treatment the amount of intervening wakefulness in the first six hours of sleep decreased significantly more in the oestrone group than in those on placebo. Between the baseline period and the second treatment month the oestrone group showed a significantly greater decrease in the total amount of intervening wakefulness and in the frequency of awakenings. Their total amount of rapid eye movement sleep increased. Mood and anxiety improved and the number of hot flushes decreased to a similar degree in both groups.

Although oestrogen did reduce the number of episodes of wakefulness in perimenopausal women complaining of insomnia, its effects on their psychological symptoms were little different to those of placebo.

University Department of Psychiatry, Royal Edinburgh Hospital, Edinburgh EH10 5HF

JOAN THOMSON, MB, MRCPSYCH, Abbott research fellow
IAN OSWALD, MD, FRCPSYCH, professor of psychiatry

Introduction

The perimenopausal period has long been considered to be a time of increased morbidity, and various epidemiological surveys[1-3] have shown that complaints of hot flushes, insomnia, depression, and anxiety are especially common at this time. The symptoms may be due to hormonal changes, but it is also possible that the psychological symptoms might be due to fear of aging or to the social changes of middle age. Jaszman[1] and Ballinger[4] have inferred that insomnia is due to hormonal changes, since their surveys have shown that the incidence of the complaint rises as oestrogen levels fall in the perimenopausal period. Other possible causes are aging, anxiety, and depression, all of which are associated with sleep disturbance.[5-7]

Hormone replacement therapy has been used to treat menopausal symptoms since 1896 but remains controversial. McKinlay and McKinlay[8] reviewed the many studies of hormone replacement therapy but found that results were conflicting and that studies lacked consistency in defining the menopause, the symptoms associated with it, and the age group to be studied.

We therefore carried out a double-blind controlled study of the effect of oestrogen therapy on sleep, mood, anxiety, and hot flushes in perimenopausal women.

Patients and methods

Patients were referred by local general practitioners. All were aged 45-55 and had had amenorrhoea for at least three months and symptoms of insomnia, depression, anxiety, and hot flushes. They received no other medication, had no contraindications to oestrogen therapy, and were asked to abstain from alcohol for the duration of the study.

Each patient was studied for 14 weeks, and throughout this time they attended the sleep laboratory in pairs on one night each week for electrophysiological recording of sleep. In the first six weeks all patients received a placebo. In the remaining eight weeks one of each pair received piperazine oestrone sulphate in a dose of 1·5 mg twice