

Mode of Transmission of *Pseudomonas aeruginosa* in a Burn Unit and an Intensive Care Unit in a General Hospital

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The transmission of *Pseudomonas aeruginosa* was studied in the burn unit and the intensive care unit of a 650-bed hospital. There was a tendency among patients in the burn unit to yield more than one type of *P. aeruginosa*, and several patients shared the same types at a particular point in time, suggesting cross-contamination among patients. Similar observations were made in the intensive care unit. Cultures from the hands of nurses caring for these patients yielded the same types of *P. aeruginosa*, suggesting the direct handling of patients by the nursing personnel to be the principal mode of transmission.

Nosocomial infections with *Pseudomonas aeruginosa* (hereafter referred to as *Pseudomonas*) in severely ill patients are rather common (3, 9, 10). The sources of the organism have been shown to be mostly inanimate moist objects or objects containing water (1, 2, 5, 7). However, the mode of spread of *Pseudomonas* in a ward once the organism has colonized a patient has not been clearly defined.

Recently, Lowbury et al. (7) presented data implicating the hands of nursing personnel in the spread of *Pseudomonas* in patients with tracheostomies in an intensive care unit.

Additional evidence is presented here indicating the hands of nursing personnel as a major means of transmission of *Pseudomonas* from patient to patient in the burn unit and the intensive care unit.

MATERIALS AND METHODS

Cultures. Approximately 750 isolates of *Pseudomonas* were recovered from the burn unit (7 beds) and the intensive care unit (10 beds) during the course of 1 year. Cultures from the burn unit were from burn wounds, sputa, and urine specimens; those from the intensive care unit were from postoperative wounds, sputa, urine specimens, and tracheostomies.

Hand cultures of the nurses working in the burn unit and the intensive care unit were taken during the morning hours (8 to 11 AM) within a 4-week period. Although most nurses submitted multiple cultures, the same nurse was never cultured more than once a day. Hand cultures were taken by impression on cetrinide-agar in Rodac plates (0.03% cetrinide in Trypticase soy agar, BBL). Environmental ob-

jects (sinks, washing basins, floors) were cultured with a moist cotton swab on 5% sheep blood-agar and cetrinide-agar. Saline and medicated creams were cultured in Trypticase soy broth (BBL) and subcultured on blood-agar. Air cultures were made on blood-agar settle plates.

Feces were cultured in cetrinide broth, and then subcultured on MacConkey Agar (Difco) and cetrinide-agar. All *Pseudomonas* strains were identified by their colonial morphology, production of oxidase, fluorescence, motility, and glucose oxidation.

Pyocine typing. The technique used was that of Darrell and Whaba (4) as modified by Zabransky and Day (11); 11 indicator strains (kindly supplied by Ronald Zabransky) were used. A particular pyocine type was determined by the inhibition it produced on certain indicator strains.

RESULTS

All *Pseudomonas* isolates from clinical specimens, the environment, and the hands of nursing personnel in the burn unit and the intensive care unit were pyocine-typed. Pyocine-typing of these isolates established 14 types as listed in Table 1. About 2% of all cultures were nontypable. The frequency of distribution of the isolates will be reported in a separate communication.

Pyocine types of *Pseudomonas* recovered from four burn patients are shown in Table 2. Each patient yielded several types during hospitalization, with a tendency to share the same type during particular intervals. This tendency to cluster was shown for type T, which was recovered from four patients within a 10-day interval, and also for type B-3, which was re-

TABLE 1. *Pycocine typing pattern of Pseudomonas aeruginosa recovered in the burn unit and the intensive care unit^a*

Type	Indicator strains										
	M8	B10	S17	B26	B39	A52	10/55	283	577	584	593
B-2	+	+	+	—	+	+	—	+	+	—	—
B-3	+	+	+	—	+	+	—	—	+	+	+
B-7	+	+	+	—	+	+	—	—	+	—	+
D-2	+	—	+	—	+	—	—	+	+	—	—
E-2	+	+	+	+	+	+	—	+	+	—	—
E-6	+	+	+	+	+	+	—	+	+	—	+
F-2	+	+	—	—	+	+	—	+	+	—	—
F-4	+	+	—	—	+	+	—	+	+	+	+
F-6	+	+	—	—	+	+	—	+	+	—	+
I	—	+	—	—	—	—	—	—	—	—	—
J-2	+	+	—	+	+	+	—	+	+	—	—
J-6	+	+	—	+	+	+	—	+	+	—	+
T	—	+	—	+	+	+	—	—	—	—	—
U	—	+	—	—	—	+	—	—	—	—	—

^a Inhibition of growth by pycocine production is indicated by the plus signs.

TABLE 2. *Pseudomonas aeruginosa isolated from wounds of patients in the burn unit*

Patient	Pycocine types				
	I	T	U	B-3	D-2
Pe	5/6 ^a	6/29	—	—	—
Hi	6/16	6/26	7/9	6/3	—
Dr	—	7/6	—	6/16	—
Kr	—	7/1	7/9	6/29	7/9

^a Date of first isolation (month/day).

covered from three patients. The pycocine types of *Pseudomonas* recovered from patients in the intensive care unit are shown in Table 3. Here again, there was a tendency among patients to share the same pycocine type within a relatively short period of time. Of special interest are types F-6 and F-2, which were shared by four and eight patients, respectively.

To examine the mechanism of transmission of *Pseudomonas* in the burn unit and the intensive care unit, the hands of nurses and several environmental objects were cultured. As shown in Table 4, 5 of 21 nurses examined in the burn unit yielded *Pseudomonas* from their hands, and in the intensive care unit 4 of 20 nurses yielded *Pseudomonas*. Also shown in Table 4 are the sinks maintaining *Pseudomonas*. The sinks in the burn unit yielded *Pseudomonas* more often than the ones in the intensive care unit. No *Pseudomonas* was recovered from the feces of six patients within 3 days after admission. *Pseudomonas* was not recovered from the other environmental samples as listed in Table 5.

Table 6 shows the pycocine types and first

TABLE 3. *Pseudomonas aeruginosa isolated from patients in the intensive care unit*

Patient	Pycocine types				
	F-6	E-6	F-2	D-2	B-2
Wa	3/5 ^a	—	—	—	—
Am	3/5	—	—	—	—
Di	—	3/9	3/12	—	—
Ra	3/12	—	—	—	—
Fl	—	—	3/18	—	—
Pu	—	—	3/22	—	—
Ma	—	—	3/23	—	—
Ne	—	—	4/5	—	—
Wa	—	—	4/12	—	—
El	—	—	—	4/20	—
Je	—	—	4/20	—	—
Ot	4/21	—	—	—	—
Sa	—	—	—	—	4/26
Ar	—	—	—	—	4/27
Wh	—	—	—	4/27	—
Ma	—	—	4/29	—	—

^a Date of first isolation (month/day).

dates of recovery of *Pseudomonas* from the patients, the hands of nurses, and the sinks in the burn unit and the intensive care unit. As can be seen, the patients and the nurses shared a particular type most frequently. The data show only one instance, in the intensive care unit, in which the sink contained the same type (J-6) as that recovered from one of the patients, whereas this type was not found on the hands of the nurses.

DISCUSSION

Initially, it was observed in the burn unit and also in the intensive care unit that several

TABLE 4. Recovery of *Pseudomonas aeruginosa* in the burn unit and the intensive care unit

Ward	Nurses (hands)	Environment (sinks)
Burn unit	5/21 ^a	6/10
Intensive care unit	4/20	2/12

^a Positive/total cultured.

TABLE 5. Specimens from which *Pseudomonas aeruginosa* was not recovered (burn unit)

Specimen cultured	No. of times cultured
Floor	6
Air	6
Tank (hydrotherapy)	10
Saline	3
Purified water	3
Medicated cream	4
Washing basins	10
Water containers	10
Suction tubes	10
Feces	6 ^a

^a Patients tested within 3 days after admission.

TABLE 6. *Pseudomonas aeruginosa* recovered from patients, hands of nurses, and the environment in the burn unit and the intensive care unit

Ward	Pyocine type			
	Patient	Nurses (hands)	Environment (sinks)	
Burn unit	B-7 (1/8) ^a	B-7 (1/14)	F-4 (1/19)	
	F-2 (1/8)	F-2 (1/21)	D-2 (1/21)	
	F-2 (1/20)	F-2 (1/26)	F-2 (1/26)	F-2 (1/26)
		F-2 (1/26)	F-2 (1/26)	E-2 (1/26)
		F-2 (1/26)	U (1/28)	NT ^b (1/28)
Intensive care unit	D-2 (1/5)	D-2 (1/4)	J-6 (1/20)	
	J-2, D-2 ^c (1/5)	D-2 (1/4)	NT (1/20)	
		J-2 (1/4)		
	D-2 (1/8)	J-2 (1/8)		
	D-2 (1/8)			
	J-6 (1/13)			

^a Date of first isolation (month/day).

^b NT = nontypable.

^c Specimens from two different sites of the same patient

patients shared the same types of *Pseudomonas* during comparatively short periods of time. Cross-infection from patient to patient was therefore highly suspected. Cultures of the hands of the nurses who were working in the wards yielded the same types of *Pseudomonas* as the patients, thereby indicating that direct

handling by nursing personnel constituted the major means of cross-infection. The hands may have become contaminated easily by changing bedding and dressings of infected patients.

Further evidence that direct handling is a major factor in the spread of *Pseudomonas* was shown during an outbreak of type B-1 in a premature nursery of a neighboring hospital (Stinson, *personal communication*). During an outbreak involving 42 infants there, the transfer of *Pseudomonas* to new babies dropped significantly after the enforcement of rigid hand washing.

In this study, *Pseudomonas* was not recovered from stools of newly admitted patients in the burn unit. Lowbury and Fox (6) found only 3% of the population to carry *Pseudomonas* in feces; however, others have suggested that fecal contamination plays a major role as a source of infection (8).

Patients receiving chemotherapeutics and antibiotics for prolonged periods of time acquire *Pseudomonas*. Young showed that the acquisition of the organism increases with hospitalization time (L. S. Young, R. D. Meyer, and D. Armstrong, *Bacteriol. Proc.*, p. 79, 1971). Probably patients already carry *Pseudomonas* in their saliva or stools when transferred to the intensive care unit from other wards. These patients then become sources of the organism, which may in turn be easily spread through direct handling by the nursing personnel to other patients.

The original sources or reservoirs of *Pseudomonas* in our units have not been recognized as yet. Others have reported that *Pseudomonas* gained entrance into a ward and colonized patients via contaminated moist objects such as inhalation therapy equipment (2), a shaving brush (1), or a resuscitator (5).

The data show the sinks to be contaminated with *Pseudomonas*, in keeping with reports by others (5, 7). The sinks are probably not contributory to the transmission of *Pseudomonas*, as evidenced by the sequel to the enforcement of rigid hand washing with an iodophore scrub (Betadine) along with use of gloves during wound dressing in the burn unit. This procedure eliminated colonization of *Pseudomonas* during a 5-month period, a fact which supports direct handling as the mode of transmission. However, within the same time period, the infection rate due to *Pseudomonas* did not change drastically in the intensive care unit. Strict hand washing had not been enforced owing to the type of interventions taking place in that ward. Also, the continuous use of inhalation equipment and respirometers and the

transfer of colonized patients from other wards compounded the chances of contamination.

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