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Serious Nosocomial Infection Caused by *Morganella morganii* and *Proteus mirabilis* in a Cardiac Surgery Unit

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In July and August 1981, five patients in the cardiac surgery unit of the Bristol Royal Infirmary developed septicemia caused by *Morganella morganii, Proteus mirabilis*, or both of these species. Three of the patients had serious wound infections, and three of the patients died. Typing of the *M. morganii* isolates by O-serotyping and of the *P. mirabilis* isolates by O-serotyping, proticine production and sensitivity, and the Dienes reaction confirmed cross infection by both species. Although *M. morganii* has been regarded as a relatively unimportant human pathogen in the past, it may prove to be an important cause of nosocomial infection in the future.

In 1971, Adler and his co-workers studied the clinical and epidemiological characteristics of *Proteus* infections in a general hospital (2). This investigation included 71 patients with bacteremia. Although the majority of these patients (64 [90%]) were infected with *Proteus mirabilis, Proteus morganii* (*Morganella morganii*) was isolated from six patients. Few other reports of serious infection due to *M. morganii* have been made (14), and, to our knowledge, there has been only one report of cross infection by this species. Tucci and Isenberg (22) described a hospital cluster epidemic of 13 *M. morganii* infections involving 11 patients. Only two of these patients had bacteremia, and no deaths occurred. The isolates in this study were not typed.

P. mirabilis, however, is a well-known cause of clinically significant infection, and several outbreaks of nosocomial infection with this species have been described (7, 8, 20). Typing methods are well established and include O- and H-serotyping (10, 13, 16), proticine production and sensitivity typing (3, 17), bacteriophage typing (11, 12), and Dienes typing (10, 12, 21).

We here report an outbreak of serious infection with septicemia in which the two species, *M. morganii* and *P. mirabilis*, were both involved. Typing of both of these species enabled us to assess the full extent of the outbreak.

MATERIALS AND METHODS

Surveillance of patients. All patients admitted to the cardiac surgery unit have routine preoperative nose, throat, and urine samples sent for culture. In the postoperative period a urine sample and a sputum sample are cultured twice a week until the patient is discharged. Other specimens, including wound swabs and blood cultures, are taken only when clinically indicated. During the surveillance period, from the last week of July to the first week of September, a wound swab was taken from every patient on the second postoperative day and all intravenous line tips were cultured. On two occasions, in August, feces from patients in the unit were examined for the presence of *Proteus* and *Morganella* species.

Surveillance of staff and environment. A search was made for a possible common source of the outbreak. The operating theatre records were examined to detect possible links among the infected patients, theatre used, operating team, anaesthetists, and pump attendants. It was noted that all of the infected patients were under the care of one surgeon, and therefore variation in management between the two cardiac surgeons was investigated. Nose and axilla swabs and hand impression plates were taken from members of the operating teams. The ward and ward procedures were also examined, with special attention being given to the intensive care area. Possible environmental sources in the theatre and ward were swabbed.

Isolation and identification of bacteria. In addition to the isolates from the patients with septicemia, during the surveillance period all non-lactose-fermenting, urease-positive isolates from other patients on the unit were kept for further investigation. For the detection of fecal carriage of *Proteeae*, specimens were cultured for 40 h on colistin agar (blood agar base infusion agar [BBL Microbiology Systems, Cockeysville, Md.], supplemented with colistin sulfate [100 mg/liter], lactose [10 g/liter], and neutral red [10 mg/liter]).

All isolates were identified, according to the criteria of Brenner et al. (5), by their reactions in the following

biochemical tests: urease activity, phenylalanine deamination, indole and hydrogen sulfide production, ornithine decarboxylase activity, and acid production from mannitol, inositol, adonitol, trehalose, maltose, xylose, and mannose.

Typing of *P. mirabilis* and *M. morganii* isolates. Isolates were serotyped on the basis of their somatic (O) antigens by slide agglutination and passive hemagglutination according to procedures previously described (15, 16). By methods also described previously (17), *P. mirabilis* isolates were tested for proticine production and susceptibility to proticines. Differentiation of *P. mirabilis* strains by the Dienes test was performed on blood agar (BBL blood agar base infusion agar containing 1.5% agar with 5% horse blood). All isolates were tested against one another, in duplicate, with five tests per plate. The plates were read after 18 h of incubation in air at 30°C. Poorly swarming strains were encouraged to swarm by subculturing them onto semisolid agar before testing.

RESULTS

Epidemiological history of the outbreak. The cardiac surgery unit of the Bristol Royal Infirmary is a 15-bed, self-contained unit in which two cardiac surgeons operate on approximately 300 adults and children each year. The patients are admitted 3 or 4 days before surgery. From the operating theatre they return directly to the unit, where they are nursed in one of four intensive care beds for the immediate postoperative period, usually 36 h, until they no longer require ventilation or monitoring.

(i) Case 1. On 25 June 1981, a 49-year-old woman was admitted for mitral valve replacement. On 1 July, the second postoperative day, she developed acute pancreatitis, which was treated with peritoneal lavage. Two days later she developed septicemia and *P. mirabilis* was isolated from blood cultures and peritoneal fluid. She remained a difficult medical and nursing problem until her death on 3 August.

(ii) Case 2. A 37-year-old man was admitted on 3 July 1981 for coronary artery bypass surgery. Five days after the operation, he became febrile and there was a bloodstained discharge from his chest wound. Blood cultures yielded *M. morganii*. A wound swab yielded both *P. mirabilis* and *M. morganii*. His fever persisted despite adequate gentamicin therapy, to which the bacteria were susceptible, and he died suddenly on his 10th postoperative day. Blood cultures taken at this time again yielded *M. morganii*.

(iii) Case 3. A 55-year-old man was admitted on 3 July 1981 for aortic valve replacement on 8 July. He remained pyrexial during the postoperative period. On 13 July his chest wound broke down and both *P. mirabilis* and *M. morganii* were isolated together from blood cultures and a wound swab. The septicemia was successfully treated with intravenous gentamicin, but his wound continued to discharge until his transfer from the ward on 27 July.

(iv) Case 4. A 59-year-old man had an aortic valve replacement on 23 June 1981, and he was discharged home well on 5 July. On 17 July he was readmitted to a medical ward with a high fever and a deep sternal wound infection. Blood cultures and wound swabs both yielded *P. mirabilis*.

(v) Case 5. A 55-year-old woman was admitted on 16 July for a mitral valve replacement on 21 July, and the immediate postoperative period was uneventful. On 3 August she became pyrexial, *M. morganii* was isolated from blood cultures, and intravenous gentamicin was commenced. Her clinical condition deteriorated, and she died on 8 August. At postmortem the pericardial cavity contained a large hematoma secondary to perforation of the ascending aorta. There was no evidence of infection, and no source for the septicemia was found.

Typing of *P. mirabilis* and *M. morganii* isolates. The results of typing the isolates of *P. mirabilis* and *M. morganii* are summarized in Table 1. Of four of the patients with septicemia, *P. mirabilis* serotype O:5/26 (P/S type 3/1,8) was isolated from three and *M. morganii* serotype O:13 was isolated from three. The fifth patient (case 4) had a *P. mirabilis* strain of a different O serotype (O:201) and P/S type (4/1,7,10) isolated from blood, wound, and urine.

Excluding the patients with septicemia, specimens from 12 of 44 other patients on the unit between 1 July and 1 September yielded *Proteus* or *Morganella* species. Isolates from eight were available for study. *P. mirabilis* was isolated from four patients, *M. morganii* was isolated from three, and *Proteus vulgaris* was isolated from one. The epidemic strains were isolated from only two of these patients: *P. mirabilis* O:5/26 from one and *M. morganii* O:13 from the other. The temporal relationship among patients from whom the epidemic strains were isolated is shown in Fig. 1.

The feces from 16 patients were examined. *Proteus* species were isolated from three patients, and *M. morganii* was isolated from one. No patient with a positive culture had a significant growth of the same strain from urine. Of the patients with septicemia, a feces sample from case 5 only was examined, and *M. morganii* was not isolated.

Neither *P. mirabilis* nor *M. morganii* was isolated from any member of the staff or from the environment—operating theatre or ward. Examination of the theatre records failed to show any link among the infected patients. The two surgeons' management of patients varied on several points, but no fault in procedure was found.

TABLE 1. Results of O-serotyping of *M. morganii* isolates and O-serotyping and proticine and Dienes typing of *P. mirabilis* isolates from patients with septicemia (cases 1 to 5) and other patients in the cardiac surgery unit (cases 6 to 12) between 1 July and 1 September 1981

Case	Source	Date	Species	Serotype	Proticine type	Dienes test[a]
1	Blood	3 July	*P. mirabilis*	O:5/26	P3/S1,8	A
	Blood	4 July	*P. mirabilis*	O:10	P3/S1,13	C
	Sputum	5 July	*P. mirabilis*	O:5	P6/S2,3	B
	Peritoneal fluid	5 July	*P. mirabilis*	O:5/26	P3/S1,8	A
2	Blood	12 July	*M. morganii*	O:13		
	Blood	13 July	*M. morganii*	O:13		
	Blood	17 July	*M. morganii*	O:13		
	Wound	15 July	*M. morganii*	O:13		
	Wound	15 July	*P. mirabilis*	O:5/26	P3/S1,8	A
3	Blood	13 July	*P. mirabilis*	O:5/26	P3/S1,8	A
	Blood	13 July	*M. morganii*	O:13		
	Wound	14 July	*P. mirabilis*	O:5/26	P3/S1,8	A
	Wound	14 July	*M. morganii*	O:13		
	Wound	20 July	*P. mirabilis*	O:5/26	P3/S1,8	A
	Wound	20 July	*M. morganii*	O:13		
4	Blood	17 July	*P. mirabilis*	O:201	P4/S1,7,10	D
	Wound	17 July	*P. mirabilis*	O:201	P4/S1,7,10	D
	Urine	17 July	*P. mirabilis*	O:201	P4/S1,7,10	D
5	Blood	3 August	*M. morganii*	O:13		
6	Urine	20 July	*M. morganii*	O:1(1ab/19)		
7	Feces	7 August	*P. mirabilis*	O:13/18/30	P0/S0	E
8	Urine	8 August	*P. mirabilis*	O:3/28	P2/S0	F
9	Urine	10 August	*M. morganii*	O:13		
10	Nose	11 August	*P. mirabilis*	O:5/26	P3/S1,8	A
	Sputum	15 August	*P. mirabilis*	O:5/26	P3/S1,8	A
11	Urine	13 August	*P. mirabilis*	O:20w/204w	P5/S10	G
12	Feces	19 August	*M. morganii*	O:1(1ad/1ab/19)		

[a] Isolates of the same group A, B, C, D, E, F, or G showed no zone of inhibition when tested against each other; i.e., they were identical strains. Isolates in different groups did show zones of inhibition when tested against each other.

DISCUSSION

Until July 1981 only sporadic cases of *P. mirabilis* or *M. morganii* septicemia were observed in our hospital. When three patients in the cardiac surgery unit developed septicemia due to these species within a 2-week period, a full investigation was made. We failed to detect an environmental source in either the operating theatre or the ward. However, since the patients could have been infected within a few days of one another, such a source may have been excluded before environmental screening was performed. Other workers have stressed the importance of patients acting as reservoirs for epidemic strains of *P. mirabilis* (8). It is possible that case 1 introduced the epidemic strain of *P. mirabilis* into the unit. This patient was shown to be carrying a *Proteus* species in her nose in February 1981, and a preoperative urine sample taken soon after admission yielded small numbers of *Proteus* on culture. Unfortunately, neither of these isolates was available for typing. Chow et al. (8) found that proximity to another case was a significant factor in their *P. mirabilis* outbreak. Cases 2 and 3 were in the intensive care section together at a time when the work load was heavy. Case 2 was admitted to the position in intensive care vacated by case 1; case 1 was excreting *P. mirabilis* O:5/26 from peritoneal drains when she was transferred from this section. Despite antibiotic therapy, case 3 continued to excrete both species from his wound during his prolonged stay in the ward and there-

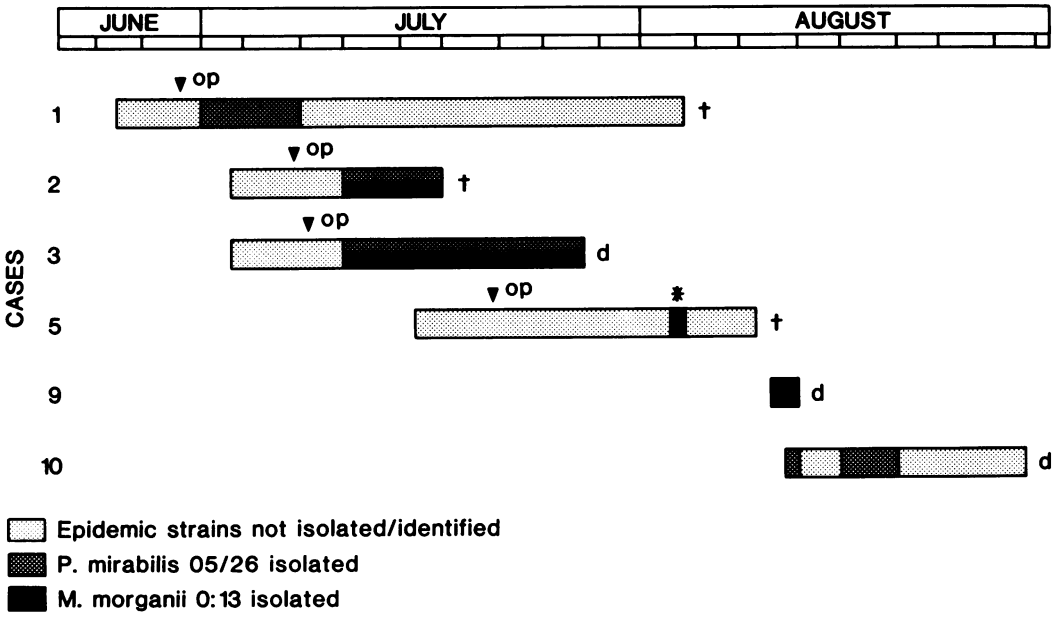

FIG. 1. Temporal relationship between patients known to be infected or colonized with *P. mirabilis* O:5/26 or with *M. morganii* O:13 or with both strains. Isolation of the epidemic strain from a patient during a given 3- or 4-day period (Wednesday to Friday or Saturday to Tuesday) is shown as infection or colonization for that period. Symbols and abbreviations: ▼ op, day of operation; †, death of patient; d, discharge of patient; *, isolation from blood culture only.

by was a possible source of infection for other patients.

The epidemic strains were isolated from two other patients on the ward during the surveillance period. Both of these patients were admitted in August, when no patient on the ward was known to be carrying the strains. *P. mirabilis* O:5/26 was isolated from a nose swab taken from one of the two patients within 24 h of admission. The other patient, a child found to be carrying *M. morganii* O:13, was only admitted to the ward for 1 day. These findings may merely reflect the prevalence of these serotypes in the Bristol community. Since August 1981, no further cases of septicemia caused by these strains have occurred in the cardiac surgery unit.

It was only when the *P. mirabilis* isolates from cases 1, 2, 3, and 4 were compared by the Dienes test that it was appreciated that case 4 was not involved in the outbreak, as was first thought. The Dienes test is a simple rapid test that can be used by any laboratory to compare the identities of strains of *P. mirabilis*. Some workers testing random isolates have found it to be unreliable (10, 12), but Skirrow (20) found this test valuable for the detection of cross infection and Senior (18) also found it to be a highly discriminating method. In this investigation the results of the Dienes typing correlated well with those of the other two typing methods used.

This is the second report from Britain of an outbreak of serious infection by serotype O:26, Skirrow (20) having described an outbreak of meningitis in Birmingham caused by the same serotype. This may merely reflect the prevalence of this type in Britain; de Louvois found 6.3 to 8.5% of clinical isolates of *P. mirabilis* from Birmingham to be of this type (10). It may indicate, however, that *P. mirabilis* strains with this serotype or the P3/S1,8 proticine production and sensitivity type, or both, have a greater pathogenicity than other strains. An association of the P3/S1,8 characteristic with pathogenicity within the urinary tract has been reported previously (19).

It is of interest that case 1 carried more than one type of *P. mirabilis* in different sites at the same time. This has been described previously (6) and may cause confusion when the epidemiology of this bacterium is being investigated.

In the past, *M. morganii* has been called "a quite unimportant organism," and its role as a pathogen in human infections has been doubted (9). Its epidemiology has not been extensively investigated, and typing by O-serotyping is performed by only a small number of laboratories in the world (15) and has not previously been applied to a reported hospital outbreak. In 1981, apart from the five cases reported here, members of the tribe *Proteeae* caused septicemia in

10 other patients at the Bristol Royal Infirmary: *P. mirabilis* in 4, *P. vulgaris* in 3, *M. morganii* in 2, and *Providencia stuartii* in 1. This high incidence of septicemia caused by the so-called indole-positive *Proteus* species may reflect the increasing use of broad-spectrum antibiotics (1, 4, 23); the *M. morganii* isolates in this outbreak, as distinct from the *P. mirabilis* isolates, were resistant to ampicillin, cephradine, and cefuroxime. The finding in this outbreak of cross infection with serious morbidity and mortality due to *M. morganii* suggests that it may become an important opportunistic nosocomial pathogen in the future.

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