O Antigens of *Proteus mirabilis* and *Proteus vulgaris* Strains Isolated from Patients with Bacteremia

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During the period of 1971 to 1979, 172 *Proteus mirabilis* and 17 *Proteus vulgaris* strains were collected from blood cultures. Of these strains, 144 could be grouped into 25 O antigens. The most common antigens were O3, O23, O10, O30, and O24, which represented 46.1% of all strains. The O antigen distribution of strains isolated from blood cultures did not differ significantly from that of fecal and urinary strains. No particular O antigen could thus be defined as a virulence factor in bacteremia.

The presence of specific antigens of certain species among the *Enterobacteriaceae* has been associated with high virulence in various types of infections. The enhanced pathogenicity of *Salmonella typhi* as compared with other *Salmonella* species is well known and has been attributed to Vi antigen (4). In neonatal meningitis caused by *Escherichia coli*, a marked dominance of K1-containing strains has been found, suggesting that this antigen is associated with virulence (11). It is also well known that some 8 to 10 *E. coli* O antigens dominate among strains which cause acute pyelonephritis in children, although more than 150 different *E. coli* O antigens have been identified (7, 10).

*Proteus mirabilis* and *Proteus vulgaris* have no regular K antigen (4), and the search for a correlation between virulence and surface antigens has focused mainly on the O antigen (6, 12).

A previous report showed that strains containing the *Proteus* O3 antigen were especially common among *P. mirabilis* and *P. vulgaris* isolated from blood, and it was suggested that the O3 antigen thus might be related to virulence (6). That investigation was made during a limited time period with the risk of influence of seasonal variations in O antigen distribution. The present study was made over a longer period, 9 years, and included an analysis of the O antigen distribution among *Proteus* strains isolated from blood cultures.

**MATERIALS AND METHODS**

All isolates of *P. mirabilis* and *P. vulgaris* were obtained from a total 148,038 blood cultures submitted to the Bacteriological Laboratory, Göteborg, Sweden, during the period 1971 to 1979. The laboratory receives samples from four major hospitals, and the population in the area, in the western part of Sweden, is about 700,000. Approximately 16,400 blood cultures were processed each year. The *Proteus* strains were stored as deep agar stab cultures. Duplicates were excluded. About 12 *Proteus* isolates were lost during the 9-year period. *Proteus morganii* and *Proteus rettgeri* strains were not included in the study, as the O serotyping system of Kaufmann and Perch (4) only comprises *P. mirabilis* and *P. vulgaris*.

*Proteus* O serotyping was performed as earlier described (6). In brief, an overnight nutrient broth culture of each strain to be tested was autoclaved for 0.5 h. One drop of this suspension was mixed with one drop of diluted *Proteus* O antisera (final dilution, 1:800 to 1:1,600) in wells of Perspex agglutination trays. Agglutinations were read after overnight incubation at 50°C. Monovalent antisera were available against the following O antigens: 1, 3 through 17, 19, 20, 23 through 33, 35, 36, 38, 40, 41, 44, 49, and provisional O antigens A through E. The same rabbit antisera were used in this study and the previous study (6).

Statistical evaluations were performed by using the chi-square test.

**RESULTS**

A total of 172 *P. mirabilis* and 17 *P. vulgaris* strains were collected, 144 of which (76.2%) could be grouped into 25 O antigens (Table 1). A total of 17 spontaneously agglutinating and 28 non-agglutinating strains were also found. The most commonly encountered O antigens, O3, O23, O10, O30, and O24, made up 46.1% of all strains. In Table 1 the O antigen distribution for each year is also given. O3 strains were common in 1972 and 1973 (nine and seven isolates, respectively) but later only two to three isolates were found each year. No such marked variation was noted for other O groups. No correlation was found between the 17 *P. vulgaris* strains and O serotypes.

The age and sex distribution of the 189 patients (137 males, 52 females) with *Proteus* bacteremia is seen in Fig. 1. No correlation was
Table 1. O antigens of *P. mirabilis* and *P. vulgaris* strains isolated between 1971 and 1979 from patients with bacteremia

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<sup>a</sup> Strains giving strong agglutination with O13 and O30 antisera.

<sup>b</sup> O antigens 6, 7, 9, 11, 12, 16, 19, 27, 31, 32, 33, 35, 40, 41, A, B, and E.

**DISCUSSION**

In the 1940s Kauffmann and Perch set up a serological system for O and H antigen typing of *P. mirabilis* and *P. vulgaris* (reviewed by Kauffmann [4]). This has been applied for typing of *Proteus* bacteria isolated from patients.

Lányi (5) studied *Proteus* strains from children with enteritis and found the *Proteus* O groups O3 and O26 to be very common. The O3 serotype was also very frequently found in urinary, fecal, and wound specimens as reported by de Louvois (2). Sedláčk et al. (12) reported two cases of *Proteus* bacteremia, one of which was of the O3 serotype. In the investigation by Larsson and Olling (6), 23% of all blood culture isolates of *P. mirabilis* and *P. vulgaris* were of the O3 serotype. These studies suggested that strains containing the O3 serotype had a higher virulence than did strains with other O antigens because of their more frequent occurrence. Serotyping of *Proteus* isolated from blood cultures over a 9-year period, as reported in the present study, also showed that the O3 serotype was common. The frequency, however, did not differ significantly from that reported from urine and feces samples (2, 6). Also, for the other common O antigens, O23, O10, O30, and O24, similar frequencies of blood, urinary, and fecal isolates were found.

Similarly, the O antigen distribution of blood culture isolates for *E. coli* does not differ from that of urinary and fecal isolates (8). It might thus be suggested that no particular cell wall lipopolysaccharide from these two bacterial genera constitutes a virulence factor in bacteremia.

As a causative agent of bacteremia, *Proteus* is rather uncommon among the *Enterobacteriaceae*. In 1978 *Proteus* constituted 13% of enterobacteria isolated from blood cultures at the Bacteriological Laboratory (P. Larsson, unpublished data). A similar figure was found at the Boston City Hospital (Boston, Mass.) for 1972 (9).

*P. mirabilis* dominates among *Proteaeae* and, in this investigation 172 of 189 isolates (91%) were of this species. A similar figure was reported by Adler et al. (1), who studied 71 cases...
of *Proteus* bacteremia.

In this study 168 of 189 (88.9%) patients with *Proteus* bacteremia were 50 years of age or more, with a marked male dominance (72.5%). The age distribution was also very similar to that reported by Adler et al. (1). The marked male dominance among patients with *Proteus* bacteremia found in the present study might be explained by the fact that elderly men have a higher frequency of *Proteus* bacteriuria as compared with elderly women (13). Furthermore, *Proteus* bacteriuria in children is most common among boys, and the preputial flora is considered to be the origin of these bacteria (3). A spread of urinary *Proteus* to the bloodstream might explain why all eight patients of 2 years of age or less were males.

In conclusion, no particular *Proteus* O antigen was defined as a virulence factor in bacteremia. *Proteus* bacteremia dominated among the very young and the elderly, suggesting that host defense factors are of great importance in the host-parasite relationship of *Proteus* bacteremia.

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LITERATURE CITED


