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Yersinia and Yersiniosis

IT IS ONLY in the last few years that *Yersinia enterocolitica* has been recognized as an etiological agent of acute enteritis. It may therefore be grouped with *Campylobacter* (chapter 12) and the pathogenic forms of *Escherichia coli* (chapter 13) as a "new" bacterial agent of diarrheal disease—although, unlike these other two, *Yersinia* is unlikely to prove to be a major cause of diarrhea.

Description of Pathogen and Disease

The genus *Yersinia* comprises three species, each of which is essentially an animal parasite that sometimes infects man. *Y. pestis* is the causative agent of human plague and is primarily a parasite of rodents. *Y. pseudotuberculosis* is primarily a parasite of guinea pigs and other rodents and occasionally infects humans, causing a variety of pathological conditions. *Y. enterocolitica* causes gastroenteritis and other symptoms in man and infects a wide range of wild and domestic animals. Only *Y. enterocolitica* will be dealt with in this chapter because it alone out of the three is primarily an excreted pathogen.

Identification

Yersiniosis is caused by bacterial infection primarily of the intestine and blood circulatory system. The causative organism *Y. enterocolitica* most commonly gives rise to an acute enterocolitis and septicaemia. Diarrhea may be the only symptom, or it may be accompanied by abdominal pain, fever, or both. It is often difficult to distinguish the disease clinically from other enteric infections such as those produced by certain shigellae and salmonellae. However, the acute infection sometimes resembles appendicitis, and in such cases surgery will reveal inflammation of the appendix together with terminal ileitis and mesenteric adenitis. Other less frequent forms of infection include pyuria, polyarthritis, and conjunctivitis (that is, it is one of the causes of Reiter's syndrome, which involves all three), and also infections of skin, wounds, and throat.

Diagnosis is by isolation of the bacteria from fecal or blood specimens. Some of the selective media used for isolation of salmonellae are appropriate for recovery from feces, but with the important difference that an incubation temperature in the range of 22 to 29°C, rather than 37 to 42°C, is optimal. Presumptive yersinias must be typed biochemically and may be further characterized by serotyping and phage typing.

Occurrence

Although the organism was first isolated in the USA in 1923, it was not recognized as a human pathogen until the early 1960s. The first human cases of infection were diagnosed in France, Belgium, and Sweden in 1963; since then it has been identified as a human pathogen in thirty countries throughout the world. In Europe and North America, *Y. enterocolitica* may be responsible for between 1 and 3 percent of recorded acute cases of gastroenteritis, but no comparable data are yet available from developing countries. It is certain that its recorded incidence and geographical distribution are artificially low as a result of widespread inadequacies in diagnostic expertise and, hence, reporting.

Infectious agent

Y. enterocolitica possesses all the characteristics of the Enterobacteriaceae, to which family yersinias were assigned in 1966. It is a Gram-negative ovoid or rod-shaped organism measuring 0.8–3.0 micrometers by 0.8 micrometers. It is a facultative anaerobe. About thirty-four serotypes have been recognized, of which a number are characteristically associated with particular non-human animal species, whereas others are associated with several human and nonhuman animals. Serotypes O3, O8, and O9 are particularly associated with human disease.

Reservoirs

It is likely that wild animals including shrews, red foxes, hares, and beavers form a natural reservoir for *Y. enterocolitica*; domestic animals from which the pathogen has been isolated include cattle, sheep, pigs, dogs, chinchillas, and geese. The number of animal species identified as affected by yersiniosis continues to rise and now includes primates other than man. It has also been demonstrated that bivalves such as mussels and oysters effectively concentrate these bacteria, although they are unlikely to multiply in them in seawater. It has been suggested that this organism follows the same epidemic and epizootic pathways as the salmonellae (see chapter 15).

Transmission

The means by which *Y. enterocolitica* is spread are still not proven. Fecal-oral transmission is most probable, and respiratory transmission is also a possibility. Foodborne and waterborne outbreaks have been reported.

In one experiment with a human volunteer, a dose of 3.5×10^9 organisms was required to produce an infection (Morris and Feeley 1976). Under natural conditions it is likely that considerably smaller doses will produce infection in a proportion of the population. In any case, high infective doses may be obtained in contaminated food since *Y. enterocolitica* multiplies readily in many foods, even under refrigeration (Kendall and Gilbert 1980).

Incubation period

Three to seven days is the normal range.

Period of communicability

In infants and young children, the watery diarrhea may persist for 3 to 14 days. In untreated cases excretion of the organism may continue for 2–3 months. A chronic carrier state has not been demonstrated in man, but certainly exists in other animals.

Resistance

The infection has been identified in people of all age groups, but there is a much higher incidence in young children.

Epidemiology

Because *Y. enterocolitica* is a recently recognized pathogen, and possibly not a terribly important one at that, knowledge of its epidemiology is very limited. The more it is looked for, the more it is found, and the worldwide picture of its epidemiology will continue to build up slowly over the next decade. In 1966 only twenty-three cases of infection with *Y. enterocolitica* were reported worldwide (Highsmith, Feeley and Morris 1977). By 1974 this had increased to over 4,000, with most cases still being reported from Europe, where many laboratories routinely screen stool specimens for this pathogen.

The first documented foodborne outbreak of yersiniosis occurred in New York (USA; Wakelee and others 1977). Serotype O8 was isolated from children suffering from abdominal pain, fever, and, in some, diarrhea and slightly inflamed appendixes. Two hundred and eighteen children attending five county schools were affected. Out of ten possible sources of infection including water, food, and milk, only chocolate milk was associated with the illness. Serotype O8 was isolated from a carton of chocolate milk during the investigation. In the dairy plant, which supplied the schools, chocolate syrup was manually added to a large open vat of pasteurized milk. Morris and Feeley (1976) reviewed the evidence of foodborne yersiniosis. They noted that the organism is commonly found in specimens from swine slaughterhouses and has been isolated from samples of market meat, vacuum-packed beef, mussels, oysters, and ice cream. It has also been found in nonchlorinated well water used for drinking purposes.

Flies may play a role in contaminating food and thus in initiating foodborne transmission. Fukushima and others (1979) isolated *Y. enterocolitica* O3 from flies caught in the piggeries and the kitchens of two farms in Japan. *Y. enterocolitica* O3 was also isolated from a ham hung in one piggery and from the feces of pigs in both piggeries. All O3 strains were of a common phage type.

Studies of the occurrence of the various serotypes and phage types of *Y. enterocolitica* have cast doubt upon some of the more simple explanations of yersiniosis epidemiology (Mollaret 1976). Caprioli, Drapeau and Kasatiya (1978) isolated and typed *Y. enterocolitica* from 31 specimens of water and food and from 143 human specimens, in Quebec (Canada). Seventy-four percent of all isolates from human sources were serotype O3, and this was the only serotype isolated from children under 4 years old. However, no serotype O3 isolates were obtained from any environmental samples. It remains unclear whether yersiniosis is primarily an infection of nonhuman animals transmitted infrequently to man, often via food (as with salmonellosis); whether man is his own reservoir for

specific serotypes; or whether, as suggested by Mollaret (1976), animals and man both contaminate and are infected from shared environmental reservoirs.

Control Measures

Not enough is known about the epidemiology and transmission of *Y. enterocolitica* to allow any confident recommendations about control. General techniques of environmental hygiene, food hygiene, and sanitation are likely to be most effective.

Occurrence and Survival in the Environment

Little is known about the occurrence and survival of *Y. enterocolitica* in the environment. The organism has been isolated from a variety of environmental samples, especially food and water, but the isolated serotypes are often not those especially associated with human disease (for instance, see Caprioli, Drapeau and Kasatiya 1978).

Lassen (1972) isolated *Y. enterocolitica* from ten out of fifty drinking water samples in Norway. Saari and Quan (1976) surveyed rivers, reservoirs, and private wells in Colorado (USA). Forty-seven percent of 125 river sites, 11 percent of 26 reservoirs, and 1 percent of 563 wells tested contained this organism, with up to 5 distinct strains per water source. The authors noted that although *Y. enterocolitica* commonly occurs in Colorado waters, serotypes pathogenic to humans are rarely found. Harvey and others (1976) isolated *Y. enterocolitica* at ten out of thirty-four stream and lake sites in a mountainous area of California (USA) and considered that the organisms probably derived from wild animals. Kapperud (1977) isolated *Y. enterocolitica* from nine out of twenty-nine surface water samples collected in areas of Norway and Denmark, where the organism infected small rodents, shrews, and foxes.

A few outbreaks of cases of gastroenteritis in developed countries have been tentatively linked to waterborne transmission of *Y. enterocolitica*. For instance, Eden and others (1977) reported the isolation of *Y. enterocolitica* from well water at a Montana (USA) ski resort soon after an outbreak of gastroenteritis of unknown cause.

Schiemann (1978) examined 2,588 surface and well water samples, submitted to the Toronto (Canada) public health laboratory for routine bacteriological tests, for the presence of *Y. enterocolitica*. The organism was identified in a total of 44 samples taken from dug wells, drilled wells, a spring, lakes, bathing water, and a municipal supply. Five positive well samples were from treated supplies: three chlorinated and two filtered. The single positive spring sample was from a chlorinated supply, as was the single municipal sample, which was additionally treated by a home-installed filter. Water samples yielding *Y. enterocolitica* showed only light coliform contamination (the median fecal coliform count was 1 per 100 milliliters), and 25 percent of *Y. enterocolitica* positive samples were negative for both total and fecal coliforms. Bearing in mind that the author had no control over sample collection and did not inspect the water sources concerned, these findings suggest that at least some strains of *Y. enterocolitica* behave very differently from coliforms in water systems and may survive some water treatment processes.

There is, as yet, very little information on the ability of *Y. enterocolitica* to survive in the environment. Dominowska and Malottke (1971) studied the survival of *Y. enterocolitica* inoculated into various types of water and kept outdoors in Poland. The average survival time in unfiltered surface waters was 38 days in spring and 7 days in summer. In filtered water the bacteria survived 197 days in spring and 184 days in summer. Under laboratory conditions at 18–22°C, *Y. enterocolitica* at an inoculum of 10^3 per milliliter survived in tap water for about 7 days and in lake water for 28 days. However, larger inocula allowed survival beyond 77 days.

Schillinger and McFeters (1978) found a 2 log reduction in *Y. enterocolitica* concentrations in stream water at 5–8.5°C after 14 days, compared with a 3–5 log reduction of *E. coli* over the same period (t_{50} values were 63 hours for *Y. enterocolitica* and 25 hours for *E. coli*). In chlorinated tap water, however, *E. coli* ($t_{50} = 0.5$ hours) survived a little longer than *Y. enterocolitica* ($t_{50} = 0.4$ hours).

Highsmith and others (1977) demonstrated that *Y. enterocolitica* could grow in sterile distilled water at 4°C, 25°C, and 37°C, but not at 42°C, and that the organism could survive in sterile distilled water for over 18 months at 4°C. This, and other evidence presented by Highsmith and her coworkers, suggests that *Y. enterocolitica* may survive for considerable periods in cool, clean waters with a minimum of bacterial competition. By contrast, in sterilized saline waters (salinities = 0.5, 2.0, and 3.5 percent) and at various temperatures (4, 25, 37°C), an initial inoculum of 1.5×10^7 *Y. enterocolitica* per milliliter failed to survive for more than 4 days, with a 6 log reduction after only 1 day (Jamieson, Madri and Claus 1976).

No data are available on the survival of *Y. enterocolitica* in feces or sewage.

Inactivation by Sewage Treatment Processes

No information is available on the destruction of *Y. enterocolitica* in sewage treatment plants or on the occurrence of this organism in sewage. In a laboratory study *Y. enterocolitica*, serotype O6, was inoculated continuously into a model activated sludge plant (volume 1 liter, retention time 8.3 hours) at a concentration of 10^6 per milliliter. *Y. enterocolitica* and coliform removals were compared at various temperatures. Removal rates were 99.8 percent and 97 percent at 5°C, 95 percent and 80 percent at 20°C, and 99.6 percent and 98 percent at 30°C for *Y. enterocolitica* and coliforms, respectively (Lloyd, personal communication).

Inactivation by Night Soil and Sludge Treatment Processes

No information is available on the destruction of *Y. enterocolitica* by night soil and sludge treatment processes or on the occurrence of this organism in night soil and sludge. Available laboratory techniques are still inadequate for this type of investigation.

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