WATER-BORNE AND FOOD-BORNE VIRUSES

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Our knowledge of viral transmission by food and water is limited by our present techniques. Infectious hepatitis virus, for example, cannot yet be cultured in the laboratory, yet its spread through food and water has been demonstrated epidemiologically and presents a real public health problem. Most of our knowledge pertains to the enteroviruses merely because the methodology for these agents is more advanced. These viruses are quite resistant to chemicals and heat and are not destroyed by the usual sewage treatment.

With rapidly increasing population and continued re-use of water supplies in the United States, it is becoming more and more imperative that we strive to solve the problem of viruses in food and water.

The transmission of disease agents in food and water has been amply documented by generations of investigators. The bacteriologist, aided by artificial media, enrichment techniques, and years of trial and error, has achieved considerable success in detecting pathogenic bacteria in raw and finished foods and even in water. Nevertheless, there are times when the bacteriologist draws a blank in his efforts, even when circumstantial evidence points to food or water as a source of infection. The frequent cause of his failure is the “needle in the haystack,” the presence of a minute quantity of infectious agent in a mass of material or liquid.

PROBLEM OF DETECTING VIRUSES

It is not surprising that the virologist, who labors under greater technical handicaps than the bacteriologist, finds himself in difficulty when confronted with the problem of detecting viruses in food and water. It is perhaps an understatement to say that our present state of knowledge concerning food and water as vehicles for transmission of viruses is limited: the truth is that our information is very limited, chiefly because of the inadequacy of present virus techniques.

The problem appears to be one of infectious virus particle numbers. As a general rule, viral agents are present in such small quantity in food and water that it is impossible to detect them with present-day techniques, even with the aid of concentration by high speed centrifugation and the use of resin columns (7, 10, 29). In sewage, the most readily isolated viral agents are the enteroviruses, which have been demonstrated repeatedly in untreated and even treated effluent. However, even in sewage the ratio of enteric viruses to coliform bacteria may approach 1 to 100,000 or greater (7). Some viruses, though present in food and water, cannot be isolated in the usual laboratory host systems such as tissue culture and animals. The isolation of infectious hepatitis virus, for example, requires human volunteers, although some recent reports indicate progress in the propagation of this agent in eggs and tissue culture (15, 19, 20, 22, 28). Certain types of gastroenteritis, we feel, are also caused by a virus, but here again we cannot determine the mode of transmission until a suitable isolation technique is developed.

VIRUSES IMPLICATED IN EPIDEMICS

There are over 100 different viruses which thrive in the intestinal tract of man. These, therefore, can be potentially transmitted via the anal-oral route or through sewage-contaminated food and water. Such viruses cause many types of illness, from paralysis and meningitis to respiratory infection and exanthems. Among them are the polioviruses, coxsackieviruses, echoviruses, reoviruses, adenoviruses, and infectious hepatitis virus. In general, these agents are quite resistant to heat, drying, and chemicals, and therefore may be expected to survive in both water and food. Some of them, such as polio virus, are excreted in tremendous numbers in the feces, sometimes reaching over a million infectious particles per gram. Moreover, these viruses are often shed for weeks following infection.

From the foregoing statements it would appear that a contradictory situation exists. On the one hand, viruses in food and water are said to be present in such small numbers that they are detected with difficulty by the virologist. On the other hand, certain of the viruses are known to be excreted in great numbers in human feces. The answer to this apparent contradiction, in the opinion of the author, lies in the dilution that occurs in water, milk, and even solid foods, and in the virologist’s use of relatively minute amounts of inoculum for tissue culture systems.

The following viruses have been implicated in water- or food-borne epidemics:

**Polioviruses.** There is strong evidence that contaminated water may be the source of poliovirus infections. In 1957, an explosive outbreak of water-borne polio was reported in Huskerville, Nebraska (3). A probable milk-borne epidemic was reported in New York State in 1951 (21). Incidentally, it has been demonstrated that flies and their excreta may harbor live poliovirus for 11 days at room temperature and several months at lower temperatures (11), however, their significance in transmission of infection is not clear.

**Adenoviruses.** These viruses proliferate in the intestinal tract of man and may be present in sewage. Their chief importance clinically is their ability to produce acute respiratory disease. Bathing water contaminated by persons shedding the virus has caused outbreaks of pharyngoconjunctival fever and inclusion conjunctivites (4, 8, 26). Of general interest is the finding that adenoviruses have been associated with an appendicitis-like disease (30).

**Infectious Hepatitis Virus in Food.** It is well known that some of the enteroviruses may accumulate and become concentrated within the digestive system of oysters (25, 29). It is probable that the infectious hepatitis virus is similarly concentrated, for there have been many outbreaks of hepatitis in which shellfish grown in contaminated waters were the proven source of infection.

Two recent infectious hepatitis outbreaks in which food was the vehicle of transmission occurred in New Jersey in 1965 (12). In the first outbreak, cold cuts were contaminated by a delicatessen food handler. About 2-1/2 weeks before the outbreak started, a sewer backup had occurred at the delicatessen store. One of the food handlers, in mopping up the sewage-flooded floors, presumably contaminated his hands and then the cold cuts. Over 80 people purchasing these cold cuts ingested enough virus to become infected. In the other outbreak of 19 cases, the vehicle of transmission was attributed to frozen strawberries dispensed from a frozen custard establishment.

**Infectious Hepatitis Virus in Water.** There have also been many hepatitis outbreaks in which contaminated water supplies were proven sources of infection. One of the most interesting occurred in Posen, Michigan, in 1959 (32). Ninety of the 340 residents of this small village and its environs had hepatitis within the period of a few months. The village is located in a limestone region where the bedrock is exposed, with almost no overlying soil to permit filtration of surface waters. Septic tanks must be placed in holes dynamited from solid rock. The effluent from these tanks reaches many of the private wells without adequate filtration. The interconnecting channels between wells and between the surface and underlying layers of rock provide ideal conditions for the spread of infection.

One of the largest outbreaks of infectious hepatitis ever recorded occurred in New Delhi, India, in 1955-56, when over 50,000 cases of the disease resulted from ingestion of contaminated drinking water—which according to city authorities, had been “fully” treated with chlorine (31). That the hepatitis virus will survive recommended chlorination procedures is further substantiated by the findings of an investigation of an outbreak in New York State in 1961 (27).

**Psittacosis (Ornithosis, Parrot Fever).** Psittacosis is usually thought to be an air-borne infection, but transmission through handling diseased carcasses may occur. Outbreaks of psittacosis have occurred chiefly among poultry plant workers. Most of the psittacosis cases in Michigan, however, have occurred in dime-store salesladies who sell infected psittacine birds.

**Q. Fever.** This virus-like agent causes a severe pneumonia in man, very similar to psittacosis, and may be transmitted through milk from infected cows, sheep, or goats. Rather explosive outbreaks have also occurred in meat packing plant personnel (5). In southern Michigan the disease is endemic in cattle herds, but the extent of human infection is unknown. Laboratory-proven cases in humans are rare.

**Other Viruses.** It is interesting to speculate as to possible human infection by other animal viruses, and perhaps even plant viruses. The shipping fever virus of cattle, for example, is closely related, if not identical to one of the parainfluenza viruses infecting man (1). Is this bovine virus associated with human disease through handling of infected meat? Many of the enteroviruses of cattle and hogs are related to the enteric viruses of man. Do these cause human infection? We know that some viruses are capable of producing different diseases in different hosts. For example, certain of the adenoviruses which produce respiratory illness in man cause tumors when injected into another host, the hamster. Some plant viruses proliferate within their arthroped hosts. Is it possible that plant viruses may, under certain conditions, also cause disease in man?

**DESTRUCTION OF VIRUSES IN FOOD AND WATER**

Although the resistance of viruses to heat and drying does not approach that of spore-forming bacteria, still some viruses such as hepatitis and polio-virus may withstand temperature treatment approaching that of pasteurization (15, 23). The enteroviruses
are especially resistant to chlorine, a fact of importance in sewage treatment (6, 9, 14, 16, 18). Primary sewage treatment has little effect on these viruses; secondary treatment, however, by trickling filters and activated sludge, reduces counts significantly (7, 13). Effluent from the ordinary treatment plant, treated with 0.5 ppm chlorine is not free of viruses (17). Sewage can, however, be treated so that the effluent is not only free of demonstrable cytopathic human viruses, but safe for swimming and boating. Since 1962, a sewage reclamation project at Santee, California, has proved that re-use of such waters is entirely feasible in arid regions (2, 24, 29). The treatment facilities at Santee include five ponds and a huge sand-filtration bed. The fifth pond receiving fully treated water is now being used for both swimming and boating.

LACK OF DIAGNOSTIC SERVICES

If human cases of suspect viral infection occur, the virus laboratory can aid in diagnosis of the individual case. Recovery of a virus from man is relatively simple because man, in effect, concentrates the virus, as does the shellfish. It is impractical however, for the laboratory to test food or water supplies implicated in viral transmission. The methods for virus detection in foods and water are still too primitive to be undertaken by routine diagnostic laboratories.

REFERENCES