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Viruses in Faeces

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ABSTRACT

Such viruses as enteroviruses (hepatitis A may now be included in this group), rotaviruses, parvovirus-like viruses, astroviruses, caliciviruses, adenoviruses and coronaviruses may be detected in human faecal extracts. Although acute poliomyelitis is seldom accounted in developed countries, which now administer polio vaccines routinely to children, poliomyelitis is a still a considerable problem in many developing countries. In parts of India, about 3.4/1000 children have poliovirus induced deformities, infection occurring most commonly in infancy. In temperate climates, outbreaks of echovirus infection occur periodically and although small children are most frequently infected, CNS involvement is reported more commonly in those aged 25-44 years. Although most persons living in developing countries acquire immunity to hepatitis A in childhood, only about 30% of healthy blood donors in the UK have immunity. Unlike infection by hepatitis B virus, hepatitis A virus does not cause post-transfusion hepatitis or outbreaks of hepatitis among haemodialysis patients. Furthermore, hepatitis A does not induce chronic liver disease. Patients with hepatitis A virus are most infectious during the latter part of the incubation period, but once symptoms develop very little virus is present in the faeces. Rotaviruses are the commonest cause of acute non-bacterial gastroenteritis in infancy and childhood. In temperate climates, infection occurs most frequently during winter months and in children aged 6 months to 3 years. Studies in hospital have shown that 40-50% of children admitted with acute diarrhoeal disease are excreting rotavirus, but in winter the proportion may be as high as 70-80%. Rotaviruses have also been shown to cause acute infantile gastroenteritis in developing countries although there is considerable variation in the incidence of rotavirus infection among children in the tropics. Parvovirus-like viruses cause winter vomiting disease and although different serotypes have been identified, approximately 25% of outbreaks appear to be related to Norwalk agent which represents the prototype for this group viruses. Astroviruses and caliciviruses may induce acute diarrhoeal disease in childhood but they probably represent relatively minor pathogens. The role of coronaviruses remains to be established.

KEYWORDS

Enteroviruses, Echoviruses, Polioviruses, Hepatitis A virus, Rotavirus, Parvovirus-like viruses, Astroviruses, Caliciviruses, Coronaviruses.
INTRODUCTION

Since only limited space is available with which to cover the topic of faecal viruses and their syndromes, comments will be limited to points relating to the more important viruses, particularly if there have been recent developments.

The small intestine has an excellent in-built mechanism for producing large quantities of virus. In the adult it is approximately 9 metres in length but the villous infolding provides it with an extensive surface area.

There are a very large number of cells lining the villous processes and it is in these cells that virus replication generally occurs. The cells are replaced every 72 hours and it has been estimated that there are a sufficient number of cells lining the villi to cover the area of a tennis court!

In view of these facts it is perhaps surprising that virologists have only in the course of the last few years begun to examine negatively stained faecal extracts for viruses by electronmicroscopy, since the techniques employed were available 20 years ago. However, virologists did not employ them to examine faecal extracts, perhaps because they thought that if viruses were implicated in acute gastroenteritis, the number of particles would be below the critical level for electronmicroscopy. Indeed, it was veterinary workers who blazed the trail by detecting rotaviruses in the stools of animals with acute enteritis some 4-5 years before medical virologists did among children.

Paradoxically many of the viruses which are excreted abundently cannot be grown, or can only be grown with difficulty in cell cultures.

ENTEROVIRUSES

The enterovirus genus consists of the polio, Coxsackie A and B and echoviruses, all of which belong to the family of picornaviridae. These viruses are small, isometric viruses with a diameter of approximately 27 nm (Fig. 1a). They contain single stranded RNA.

![Fig. 1a. Enteroviruses (Coxsackie B5)](image)

Poliomyelitis

The widespread use of oral polio vaccines has made polio a clinical rarity in developed countries. When it does occur, it is almost invariably in unvaccinated persons, often after travel abroad. However, in developing countries, poliovirus continues to circulate; indeed, in some parts of the developing world the incidence of paralytic poliomyelitis may, if anything, be increasing.
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Studies in Vellore in 1979 among both rural and urban children showed that the prevalence of deformities induced by poliomyelitis was 3.4/1000 school children (Report, 1980).

However, the median age of onset was approximately 12 months and almost all children had acquired this by the age of 6. If this data is typical for the whole of India, then it can be extrapolated that at least 70 thousand children would have polio induced defects; a figure considerably in excess of the 9 thousand reported in WHO statistics. (The figures above are annual).

As in other parts of the tropics, oral polio vaccination is not always effective; since some 10-20% of children have had a full course of oral polio vaccine.

Other Enteroviruses

Despite the above findings, most children in developing countries have acquired immunity to polio virus by school age, most infections being sub-clinical. As with polio, most infections by other enteroviruses are mild or sub-clinical.

Although relatively little is known of the distribution and clinical features of infection in developing countries, studies in Uganda and in India have shown that a high proportion of children aged 3 years or less may be excreting enteroviruses at any one time (DomoK, I., Belayan, M.S., Fayinka, O.A. and others, 1974; John, T.J., Christopher, S., 1975). In temperate climates certain enterovirus sub-types predominate in a particular year. In 1980, Echo 30 was the predominating type of enterovirus (Communicable Disease Report, 1980).

The accumulated data from a number of studies in which the epidemiological and clinical features of enterovirus infection were studied in temperate climates, has shown that there is an increase in the number of cases throughout the summer, peaking in autumn months. Males are more frequently infected than females (ratio 2:1). Highest attack rates occur in infancy, CNS infection (usually asymptomatic meningitis) being reported in about 20% of cases. Although infection is less common in adults aged 15-44, if they are infected, the CNS is involved more frequently (50-60% of cases). In such patients, virus can readily be isolated from the CSF.

Hepatitis A virus

Hepatitis A virus is a 27nm RNA virus (Fig. 1b) with the physico-chemical characteristics of a typical enterovirus (Feinstone, S.M., Moritsugu Y., Shih J. W-K., and others, 1978).
It is transmitted from person to person by the faeco-oral route. Extensive 'point source' outbreaks may result from virus contamination of food, water, milk and shellfish. The incubation period is generally of the order of 25-30 days, patients being most infectious during the latter part of the incubation period, i.e. before symptoms appear. However, once symptoms develop, infectivity rapidly declines and it is generally no longer possible to detect virus in the stools once the patient has become jaundiced.

Sero-epidemiological studies show that there is considerable geographic variation in the prevalence of antibodies to hepatitis A virus. Acquisition of antibody is acquired early in life by a high proportion of persons living in developing countries. However, in North America and some countries in Western Europe (including the U.K.) (Banatvala, J.E., Thorogood, R.J., 1980), only about one third of adults have antibodies to hepatitis A virus and many such persons are aged 35 years or more (Banatvala, J.E., Thorogood, 1980; Szmuness, W., Dienstag,
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J.L., Purcell, R.H. and others, 1977). In England and Wales in 1969 there were over 23,500 cases of "infective jaundice" notified. By 1979 this had fallen to 3,300 cases, a reduction of over 85%. Most of this reduction can be attributed to the declining incidence of hepatitis A virus infections (Galbraith, N.S., Forbes, P., Mayon-White, R.T. 1980). Since a high proportion of young adults in the U.K. are susceptible, it is important that they should be protected from hepatitis A virus infection by the passive administration of pooled normal human immunoglobulin prior to visiting hepatitis A virus endemic parts of the world.

**VIRUSES CAUSING ACUTE GASTROENTERITIS**

Rotaviruses and parvovirus-like viruses undoubtedly cause acute gastroenteritis. However, the role of such other viruses as adenoviruses, astroviruses, caliciviruses and coronaviruses are perhaps less well established although it now seems probable that enteric adenovirus, astrovirus and caliciviruses may from time to time be associated with cases or outbreaks of acute diarrhoeal disease.

**Rotaviruses**

Rotaviruses are the commonest cause of acute non-bacterial disease in infancy and childhood. The virus particles are approximately 70 nm in diameter, contain double stranded RNA and represent a separate genus in the family of reoviridae. The virus particle has a double capsid layer, having a sharply defined smooth rim (outer capsid) surrounding spoke-like sub-units (inner capsid) which radiate outwards from a hub-like core (Fig. 1c). Some virus particles may be devoid of the external capsid.

Because of the wheel-like appearance, the term rotavirus was suggested for the viruses in this group (Flewett, T.H., Bryden, A.S., Davies, H.A. and others, 1974), and this term is now accepted for official classification.

Rotaviruses were first identified in calves (Mebus, C.A., Underdahl, N.R., Rhodes, M.B. and others, 1969) and since then, in addition to children, rotaviruses have been detected in a large number of different animal species (Derbyshire, J.B., Woode, G.N., 1978) including such non-mammalian hosts as chickens and turkeys. Not only are rotavirus detected in different animals morphologically identical but common antigens are shared. Thus antigens associated with the inner capsid are group specific whereas antigens associated with the outer capsid are species specific.
The accumulated data from a number of studies conducted in temperate climates has shown that rotaviruses may be detected in approximately 40-50% of infants admitted to hospital with acute diarrhoeal disease although in winter months the proportion may rise to 70-80% (Davidson, G.P., Bishop, R.F., Townley, R.R.W., and others, 1975). Children between the ages of 6 months to 3 years are most commonly affected. Highest levels of virus are excreted between the second and fourth day of illness (up to $10^{10}$ particles/g faeces) but a week or so after the onset of symptoms very little virus is present. However, patients with immuno-deficiency disorders may experience diarrhoea and virus excretion over a period which may extend for many months (Saulsbury, F.T., Winkelstein, J.A., Yolken, R.H. 1980). Virus is probably transmitted via the faeco/oral route and although some patients may experience respiratory symptoms, attempts to detect rotavirus in respiratory secretions have been unsuccessful (Goldwater, P.N., Chrystie, I.L., Banatvala, J.E., 1979). Since very large amounts of virus are excreted in faeces, it is not surprising that hospital acquired infection occurs commonly, particularly among children aged between 6-24 months. Infection has also been reported in newborn nurseries, but for reasons which are not clearly understood, neonatal infection is generally mild or asymptomatic (Totterdell, B.M., Chrystie, I.L., Banatvala, J.E., 1980).

Although results of studies relating to the incidence and seasonal distribution of rotavirus infection in temperate climates are broadly in agreement, results obtained from studies in developing countries show considerable variation. These may represent real differences or alternatively reflect language and other difficulties precluding obtaining specimens at optimum times for viral diagnosis. Nevertheless, rotaviruses have been shown to have a world wide distribution. Table 1 shows the incidence and seasonal distribution of rotavirus infection in various tropical countries in which studies have been carried out for sufficiently long to take seasonal factors into account.

Human rotaviruses exhibit antigenic variation. Enzyme immunoassay suggests that there are two major antigenic types of rotavirus (Yolken, R.H., Wyatt, R.G., Zissis, G., and others, 1978), whereas by neutralization tests, at least three, and even perhaps, four sub-types have been identified (Flewett, T.H., Thouless, M.E., Pilford, J.N., and others, 1978). U.S. workers employing enzyme immunoassay have shown that their two major subtypes have a world wide distribution and that sequentially acquired infections are usually the result of infection by a different serotype. Infection caused by one subtype does not appear to protect against infection by the other. It appears that infection by both serotypes occurs early in life throughout the world for by approximately 18 months of age,
### TABLE 1: Prospective studies on rotaviruses in acute gastroenteritis among children in tropical climates

| Country                | Year | No. Patients Studied | Technology       | Overall % Rotavirus Positive | Seasonal Prevalence       | %* | Reference                                                                 |
|------------------------|------|----------------------|------------------|------------------------------|--------------------------|----|---------------------------------------------------------------------------|
| India (a) Vellore      | 1976 | 50                   | EM               | 26                           | Cooler (July-Dec)         | 26 | Maiya et al., 1977, Arch. Dis. Child, 52, 482-485                           |
| (b) Calicut            | 1976 |                     | EM               | 66                           | Rainy (Nov-Dec)           | 100| Mathan, Panicker, Mathan, 1977. XVth Congress of Paediatrics, New Delhi   |
| Australia (a) Darwin   | 1975-77 | 103                | Serology (CF)    | 24                           | Rainy (Jan-Mar)           | 47 | Walker, Marshall, 1977. Personal Communication.                            |
| (b) Alice Sprints      | 1977 | 92                   | EM               | 54                           | Cooler (July)             | -  | Shnagl et al., 1977, Med. J. Austr., 1, 259-260                             |
| Guatemala (rural village) | 1964-66 | 24†                | ELISA & EM       | 14                           | None                      | -  | Wyatt et al., 1979, Am. J. Trop. Med. 28, 325-328                          |
| Costa Rica (rural and urban) | 1976-78 | 488                | ELISA            | 27                           | Low relative humidity     | -  | Mata, 1978. Abstr. IVth Int. Congress Virol.                               |
| Costa Rica (San Jose)  | 1976-77 | 137                | EM               | 38                           | Dry season (Dec-Jan)      | 60 | Hieber et al., 1978, Am. J. Dis. Child, 132, 853-858                      |
| Venezuela (Caracas)    | 1975-76 | 293                | EM               | 41                           | Cooler months (Nov-Feb)   | 72 | Viera de Torres et al., 1978, Am. J. Trop. Med. Hyg., 853-858              |
| Zimbabwe (Salisbury)   | 1974-75 | 256                | EM               | 23                           | Cooler months (May-Aug)   | 92 | Cruickshank, Zilberg, 1978, S.A. Med. J., 50, 1895-1896                   |
| Argentina (Buenos Aires) | 1978-79 | 141                | EM & CIEOP       | 32                           | Cooler month (July)       | 80 | Muchnik, Grinstein, 1979, Intervirology, 13, 253-258                       |

* % of rotavirus during seasonal prevalence
† 183 episodes of diarrhoea studied
80-85% of children have acquired immunity to both serotypes (Yolken, R.H., Wyatt, R.G., Zissis, G., and others, 1978).

Infection has also been reported among adults and it is quite possible that as with some animal species, human adults represent the main reservoir of rotavirus infection. Although most episodes of rotavirus among adults are mild or even asymptomatic, outbreaks of rotavirus infection have been reported in such communities as hospital personnel (von Bonsdorff, C.H., Hovi, T., Makela, P., and others, 1978) with little or no contact with children, including an outbreak in an intensive care unit (Holzel, H., Cubitt, D.W., McSwiggan, D.A., and others, 1980) as well as in patients in geriatric institutions (Cubitt, W.D., Holzel, H., 1980; Halvorsrud, J., Orstavik I, 1980).

Parvovirus-Like Agents And Winter Vomiting Disease

Winter vomiting disease (perhaps more appropriately termed epidemic nausea and vomiting), affects all age groups and outbreaks may occur in families, schools, or more general communities. Infection usually occurs during winter and after an incubation period of 24-28 hours the illness begins suddenly with some or all of the following features: fever, anorexia, nausea, vomiting, vertigo, abdominal pain and diarrhoea. The illness is self limiting, most patients recover within 2-3 days. There is often a high secondary attack rate, up to about one third of family or school contacts may experience similar symptoms within 24-28 hours.

The virus causing this syndrome was first detected by electron microscopy in the faecal filtrate of a patient infected as a secondary case during the outbreak of acute gastroenteritis in a primary school in Norwalk, Ohio (Kapikian, A.Z., Wyatt, R.G., Dolin, R., and others, 1972). During this outbreak it was also shown by immune electronmicroscopy that patients developed an immune response during the course of infection. Following the discovery of the Norwalk agent, similar 25-27 nm particles were detected in faecal extracts from outbreaks of winter vomiting disease in the U.S.A., U.K. as well as other parts of the world (Fig. 1e) (Table 2). However, cross-challenge studies in volunteers and immune electron-microscopy studies showed that not all strains are immunologically related.

![Fig. 1e. Parovirus-like particles](Winter vomiting disease)

Although it seemed possible that, as with rhinoviruses, there might be multiplicity of serotypes, it is encouraging that approximately 25% of outbreaks of winter vomiting disease appeared to be associated with a significant rise in antibody titre to the Norwalk agent (Kapikian, A.Z., Greenberg, H.B., Cline, W.L., and others, 1978).
TABLE 2  Principal Features of Acute Winter Vomiting (Non-Bacterial Gastroenteritis) From Which Parvovirus-like Agents Have Been Detected

| Agent & Location         | Date       | Community Involved | Proportion Attacked | Bacterial Pathogens | Virus Identified by | Size | BD in CsCl | Immune Response | Comments                                                                 |
|--------------------------|------------|--------------------|---------------------|---------------------|---------------------|------|------------|-----------------|--------------------------------------------------------------------------|
| NORWALK (Ohio) USA       | October 1987 | Primary School     | 50% pupils & staff  | Negative            | IEM                 | 27-32| 1.38-1.41 | Yes (IEM, RIA, IAMA) | Virus detected in 1972 among volunteers fed with faecal filtrates from secondary cases. Related to Montgomery Co., but not Hawaii. |
| MONTGOMERY CO. (Maryland) USA | June 1971   | Family             | Parents & 2 children | Negative            | IEM                 | 27-32| 1.37-1.41 | Yes (IEM)      |                                                                          |
| HAWAII (Honolulu) USA    | March 1971  | Family             | Parents, child & adult house contact | Negative      | IEM                 | 28-29| 1.37-1.38 | Yes (IEM)      |                                                                          |
| "W" England              | March 1983  | Boys' Boarding School | 142/850 pupils & 2 staff | Negative            | EM on CsCl gradient | 25-26| 1.38-1.40 | Yes (IEM)      | Related to Ditchling, but not Cockle. All English strains unrelated to US strain. |
| DITCHLING (Sussex) England | October 1975 | Primary School     | 30/128 pupils & staff | Negative            | EM on CsCl gradient | 21-28| 1.38-1.40 | Yes (IEM)      | Virus excretion > 4 weeks.                                                |
| COCKLE S.E. England      | Dec. 1976-Jan. 1977 | General Community | 33 incidents; 799 persons | Negative      | EM on CsCl gradient | 25-26| 1.40      | Yes (IEM)      | Pollution of shellfish by sewage.                                        |
| PARRAMATTA (NSW) Australia | August 1977 | Primary School     | 267/361 pupils & staff | Negative            | EM                  | 23-26| NT        | Yes (IEM)      | Virus excretion > 6 weeks.                                                |
| NORWALK-LIKE (NSW) Australia | Jun-Jul 1978 | General Community | > 2000 persons, mostly adults | V. Parahaemolyticus from 13.5% of oysters | EM & IEM | 27-30 | NT        | Yes (IEM)      | Oyster-associated "food poisoning", probable contamination of oysters with sewage. |

BD = buoyant density  
CsCl = Caesium chloride  
IEM = immune electronmicroscopy  
RIA = radiolmmunoassay  
IAMA = immune-adherence haemagglutination  
NT = Not tested
The 27 nm isometric viruses of which Norwalk agent is the prototype, resemble enteroviruses morphologically. However, they have a higher buoyant density in cesium chloride (1.37 - 1.4) which suggests that they may be parvoviruses. However, parvoviruses contain DNA and since the nucleic acid of Norwalk agent has not been determined, this group of viruses must for the present remain unclassified.

Enteric Adenoviruses

Although adenoviruses may be present in the stools of children with or without diarrhoeal disease, outbreaks of acute diarrhoeal disease both in hospital (Flewett, T.H., Bryden, A.S., Davies, H., and others, 1975), as well as in the community (Richmond S.J., Caul, E.O., Dunn, S.M., and others, 1979), have been associated with the faecal excretion of very large amounts of adenoviruses (Fig. 1f).

Fig. 1f. Adenoviruses

However, in contrast with adenoviruses which cause acute respiratory infection, the enteric adenoviruses which seem to be associated with acute diarrhoeal disease, can only rarely be propagated in cell culture. There is some evidence which suggests that the enteric adenoviruses may represent a separate homologous serotype quite distinct from adenoviruses which are respiratory pathogens (Kidd, A.H., Madeley, C.F., 1980).

Other Small Round Viruses

Apart from parvovirus-like viruses other 25-30 nm particles have been detected in the stools of patients with acute diarrhoeal disease. Astroviruses are approximately 25-28 nm in diameter, have an entire outer edge and a star shaped surface configuration which may be 5 or 6 pointed (Madeley, C.R., Cosgrove, B.P., 1975) (Fig. 1g). Outbreaks of astrovirus associated diarrhoea have been reported in a children's ward affecting both children and staff, some of whom later developed an immune response (Kurtz, J.B., Lee, T.W., Pickering, D., 1977). Oral administration of astrovirus-containing faecal filtrates to adult volunteers, may result in virus excretion, an immune response and the development of mild gastrointestinal symptoms (Reed, S.E., Kurtz, J.B., Lee, T.W. 1978). Astroviruses have also been identified in the stools of lambs with diarrhoea and in calf faeces, but studies by immune electronmicroscopy suggest that the strains are not related antigenically.

Caliciviruses are approximately 30 nm in diameter and have characteristic stain filled cup-like depressions on the particle's surface (Madeley, C.R., Cosgrove, B.P., 1976) (Fig. 1h). Although these viruses may be present in the stools of asymptomatic children, they have also been detected in the stools of children and
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staff during an outbreak of winter vomiting in a primary school in England (McSwiggan, D.A., Cubitt, D., Moore, W. 1978). Infection was also associated with the development of immune responses. Other small viruses which may have a rather extensive shaggy configuration may occasionally be detected in faecal extracts of patients with gastroenteritis. For want of a better term many workers call these viruses "fuzzy wuzzies". Whether these virus-like particles are associated with acute diarrhoeal disease has yet to be determined.

Coronavirus-like viruses

Coronaviruses are important causes of severe diarrhoeal disease in pigs (trans-
REFERENCES

Banatvala, J.E., Thorogood, R.J. (1980). Hepatitis A antibodies in London blood donors, medical students and patients. Lancet, 1, 595.

von Bonsdorff, C.H., Hovi, T., Makela, P., Mortin, A. (1978). Rotavirus infections in adults with acute gastroenteritis. J. Med. Virol., 2, 21-28.

Communicable Disease Report (1980). No. 41, p.3.

Cubitt, W.D., Holzel, H. (1980). An outbreak of rotavirus infection in a long-stay ward of a geriatric hospital. J. Clin. Pathol., 33, 306-308.

Davidson, G.P., Bishop, R.F., Towney, R.R.W., Holmes, J.H., Ruck, B.J. (1975). Importance of a new virus in acute sporadic enteritis in children. Lancet, 1, 242-248.

Derbyshire, J.B., Woode, G.N. (1978). Classification of rotavirus: Report from the World Health Organization/Food and Agriculture Organization comparative Virology program. J. Am. Vet. Med. Assoc., 173, 519-521.

Domok, I., Balayan, M., Fayinka, O.A., Skrtic, N., Soneji, A.D., Harland, P.S. (1974). Factors affecting the efficacy of live poliovirus vaccine in warm climates. Bull. Wld. Hlth. Organ., 51, 333-347.

Feinstone, S.M., Moritsugu, Y., Shin, J.W-K., Gerin, J.L., Purocell, R.H. (1978). In S.N. Vyas, S.N. Cohen, J.R. Schmidt (Eds.) Viral Hepatitis, Abacus Press, Chap. 4, pp.41-48.

Flewett, T.H., Bryden, A.S., Davies, H., Morris, C.A. (1975). Epidemic viral enteritis in a long-stay children's ward. Lancet, 1, 4-5.

Flewett, T.H., Bryden, A.S., Davies, H.A., Woode, G.N., Bridger, J.C., Derrick, J.M. (1974). Relationship between viruses from gastroenteritis of children and newborn calves. Lancet, ii, 81-83.

Flewett, T.H., Thouless, M.E., Pitford, J.N., Bryden, A.S., Candelas, J.A.N. (1978). More serotypes of human rotaviruses. Lancet, ii, 632.

Galbreath, N.S., Forbes, P., Mayon-White, R.T. (1980). Changing patterns of communicable disease in England and Wales. Part II - Disappearing and declining diseases. Br. Med. J., 2, 489-492.

Goldwater, P.N., Chrystal, I.L., Banatvala, J.E. (1980). Rotaviruses and the respiratory tract. Br. Med. J., 2, 1551-1552.

Halvorsrud, J., Orstavik, T. (1980). An epidemic of rota virus-associated gastroenteritis in a nursing home for the elderly. Scand. J. Infect. Dis., 12, 161-164.

Holzel, H., Cubitt, D.W., McSwiggan, D.A., Sanderson, P.J., Church, J. (1980). An outbreak of rotavirus infection among adults in a cardiology ward. J. Infect., 2, 33-37.

John, T.J., Christopher, S. (1975). Oral polio vaccination of children in the tropics. III. Intercurrent enterovirus infections, vaccine virus take and antibody response. Am. J. Epidemiol., 102, 422-428.

Kapikian, A.Z., Greenberg, H.B., Clings, W.L., Wyatt, R.G., James, H.D., Lloyd, N.L., Chanock, R.M., Ruder, R.W., Kim, H.W. (1978). Prevalence of antibody to the Norwalk agent by a newly developed immune adherence hemagglutination assay. J. Med. Virol., 2, 281-294.

Kapikian, A.Z., Wyatt, R.G., Dolin, R., Thornhill, R.S., Kalica, A.R., Chanock,
Viruses in Faeces

R.M. (1972). Visualization by immune electron microscopy of a 27 nm particle associated with acute infectious non-bacterial gastroenteritis. J. Med. Virol., 10, 1075-1081.

Kidd, A.H., Madeley, C.R. (1980). In vitro growth of some fastidious adenoviruses from stool specimens. In the press.

Kurtz, J.B., Lee, T.W., Pickering, D. (1977). Astrovirus associated gastroenteritis in a children's ward. J. Clin. Pathol., 30, 948-952.

Madeley, C.R., Cosgrove, B.P. (1975). Viruses in infantile gastroenteritis. Lancet, ii, 124.

Madeley, C.R., Cosgrove, B.P. (1976). Calciviruses in man. Lancet, 1, 199-200.

McSwiggan, D.A., Cubitt, D., Moore, W. (1976). Calciviruses associated with winter vomiting disease. Lancet, i, 1215.

Mebus, C.A., Underdahl, N.R., Rhodes, M.B., Tweihaus, M.J. (1969). Calf diarrhea (Scours) reproduced with a virus from a field outbreak. University of Nebraska College of Agriculture and Home Economics, Research Bulletin, No. 233, pp. 1-18.

Reed, S.E., Kurtz, J.B., Lee, T.W. (1976). Inoculation of volunteers with a human astrovirus. In Abstracts of the Fourth International Congress for Virology. The Hague, 30th August - 6th September, 1978. Centre for Agricultural Publishing and Documentation, Wageningen, p. 461.

Report, 1980. Annual Report of the Department of Virology Christina Medical College and Hospital, Vellore, Tamil Nadu, India.

Richmond, S.J., Caul, E.O., Dunn, S.M., Ashley, C.R., Clarke, S.K.R., Seymour, N.R. (1978). An outbreak of gastroenteritis in young children caused by adeno-virus. Lancet, i, 1178-1180.

Saulsbury, F.T., Winkelstein, J.A., Yolken, R.H. (1980). Chronic rotavirus infection in immunodeficiency. J. Pediatr., 97, 81-85.

Szmuness, W., Dienstag, J.L., Purcell, R.H., Stevens, C.E., Wong, D.C., Ikrem, H., Bar-Shany, S., Beasley, R.P., Desmyter, J., Gaon, J.A. (1977). The prevalence of antibody to hepatitis A antigen in various parts of the world: A pilot study. Am. J. Epidemiol., 106, 382-398.

Totterdell, B.M., Christie, T.L., Banatvala, J.E. (1980). Cord blood and breast-milk antibodies in neonatal rotavirus. Br. Med. J., 1, 828-830.

Yolken, R.H., Wyatt, R.G., Zissis, G., Brandt, C.D., Rodriguez, W.J., Kim, H.W., Parrott, R.H., Urrutia, J.J., Leonardo, M., Greenberg, H.B., Kapikian, A.Z., Chanock, R.M. (1978). Epidemiology of h-man rotavirus types 1 and 2 as studied by enzyme-linked immunosorbent assay. New. Engl. J. Med., 299, 1158-1161.

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