Original articles**Clinical features of acute gastroenteritis associated with rotavirus, enteric adenoviruses, and bacteria**

I UHNOO, E OLDING-STENKVIST, AND A KREUGER

Departments of Infectious Diseases and Paediatrics, University Hospital, Uppsala, Sweden

SUMMARY In a prospective one year study, comprising children with acute gastroenteritis admitted to hospital or treated as outpatients, the clinical and laboratory features of rotavirus diarrhoea (168 cases) were compared with those of enteric adenovirus (32 cases), bacterial (42), mixed (16), and non-specific (135) infections. The rotavirus disease was remarkably consistent, with a sudden onset of vomiting, a high frequency of fever and dehydration, and a mean duration of diarrhoea of 5.9 days. Outpatients excreting rotavirus had a similar but milder illness, mainly on account of less pronounced vomiting. The predominant symptom of enteric adenoviruses was long lasting diarrhoea (mean 10.8 days). Abdominal pain, bloody stools, prolonged diarrhoea (mean 14.1 days), leucocytosis, and a raised erythrocyte sedimentation rate strongly suggested a bacterial aetiology. Mixed infections caused longer lasting diarrhoea (mean 8.0 days) than rotavirus alone, but the severity of the illness was not increased. The clinical features of infection with unidentified pathogens most resembled those of bacterial infections. Respiratory symptoms were not significantly associated with any particular pathogen. Hyponatraemia and complications were uncommon.

This study showed that the clinical features of gastroenteritis with rotavirus, enteric adenoviruses, and bacteria each exhibited patterns that could guide the experienced clinician to a presumptive diagnosis.

Infectious gastroenteritis is an important cause of childhood morbidity. During the last decade major advances in laboratory techniques have made it possible to identify several new enteropathogens. Specific micro-organisms can now be identified in 60–80% of children admitted to hospital with gastroenteritis,^{1 2} and rotavirus has emerged as the single most important agent in paediatric diarrhoea throughout the world.

Previous clinical studies of acute gastroenteritis have focused on a search for features that distinguish rotavirus from non-rotavirus infections and have led to somewhat divergent results.^{3–6} The discrepancies may to some extent be due to the composition of the non-rotavirus group, which has included varying pathogens such as other viruses, bacteria, and/or unidentified agents. Furthermore, the association of respiratory symptoms with rotavirus diarrhoea has been a matter of controversy.^{3 5 6} A recent report from England outlined in detail the clinical features associated with rotavirus in comparison with well defined groups of pathogens.² Although the authors found some significant differ-

ences between the groups, they concluded that there were few clinical characteristics associated with any particular pathogen. All the above mentioned studies have concerned gastroenteritis in children admitted to hospital.

During a recent one year survey we thoroughly investigated the aetiology and epidemiology of acute gastroenteritis in 416 children, 144 of whom had been admitted to hospital and 272 of whom had not.⁷ A putative aetiological agent was detected in 77% and 63% of the patients, respectively, and rotavirus and enteric adenoviruses were the most common enteropathogens. The purpose of this paper is to describe the clinical picture of gastroenteritis in inpatients and outpatients and to compare the symptoms and signs of rotavirus infections with those of enteric adenovirus, bacterial, mixed, and non-specific infections.

Materials and methods

Virtually all children below 15 years of age with acute gastroenteritis who attended the Department

of Paediatrics of the University Hospital of Uppsala during a complete year (1981) were entered into a prospective study. Informed consent was obtained from the parents of each child. A total of 432 patients met the criteria for a diagnosis of acute gastroenteritis—that is, three or more loose stools for at least one day and for no longer than 14 days and/or vomiting and fever. Sixteen patients were excluded as stool specimens were not available. According to the severity of the illness 144 patients were admitted to hospital and 272 remained outpatients. The latter group included 56 patients with gastroenteritis for whom the clinic was consulted by telephone only.

Two hundred children matched for age (93 inpatients and 107 outpatients) with non-diarrhoeal illness admitted over the same period served as a control group. Most of these children had a respiratory infection (68%). Other diagnoses among the controls included bronchial asthma, meningitis, urinary infections, and malignant diseases.

On admission the parents were asked in detail about clinical symptoms before the hospital was contacted, such as the appearance and frequency of stools and the occurrence of vomiting, fever, abdominal pain, and concomitant respiratory symptoms. All children were interviewed, examined, and treated by the same physician (IU). Abdominal pain in the very young children was assessed by clinical appearance. Dehydration was graded as mild, moderate, or severe.⁸ During the stay in hospital additional clinical findings, parenteral rehydration therapy, and treatment with antibiotics were recorded. Two to four weeks after the first contact the parents were interviewed again and patients who had had severe symptoms or complications were re-examined.

Management of gastroenteritis consisted of a standard regimen of an initial period of treatment with oral or parenteral rehydration solutions followed by regrading on to a normal diet over four or five days, unless complications occurred.

Faecal samples from patients and controls were studied for viral, bacterial, and parasitic pathogens as previously described in detail.⁷ The following enteropathogenic bacteria were searched for: *Salmonella* species, *Shigella* species, *Yersinia enterocolitica*, *Campylobacter jejuni*, enteropathogenic *Escherichia coli*, and enterotoxigenic (heat labile) *E. coli*. The samples were examined microscopically for ova, cysts, and parasites.

All stool specimens were studied for viruses by electron microscopy, for rotavirus by solid phase immune electron microscopy, and for rotavirus and adenovirus by genus specific enzyme linked immunosorbent assays (ELISA).⁷ Specimens positive

for adenovirus were analysed further for enteric adenoviruses 40 and 41 by type specific ELISAs, DNA restriction enzyme analysis, and virus isolation.⁹

Paired acute and convalescent phase serum specimens were available from 50% of the patients and controls and were analysed for complement fixing antibodies to rotavirus and adenovirus. In addition, patients with stools positive for adenovirus were tested for haemagglutination inhibition and ELISA antibodies⁹ and those with *Salmonella* species, *Y. enterocolitica*, and *C. jejuni* for ELISA antibodies.⁷

Clinical laboratory tests included white blood counts and measurements of the erythrocyte sedimentation rate and serum electrolyte concentrations. In the case of abnormal results the tests were repeated until normal values were restored. The acid base balance was tested only in severely ill patients.

Statistical analyses were performed with χ^2 test, Mann Whitney U test, and Fisher's exact test where appropriate.

Results

A total of 416 children (228 boys and 188 girls) with gastroenteritis aged 3 weeks to 13 years were studied. The mean and median ages of the study group were 24.9 and 15 months, respectively. Most of the children were not referred cases. The reason why the parents brought their child to hospital was failure in oral rehydration, persistent and severe symptoms, or that the child was in a poor general condition. In 144 patients the illness was sufficiently severe to necessitate admission to hospital, whereas 216 children were treated on an ambulatory basis. In 56 cases the parents only consulted the paediatric clinic by telephone, and these parents were also interviewed and given detailed advice.

The three groups of patients with gastroenteritis did not differ significantly from each other in age or sex. A comparison of the clinical characteristics of inpatients and outpatients showed that the frequencies of fever, abdominal pain, and respiratory symptoms were similar in the two groups, whereas vomiting was more common and more pronounced in the inpatients (inpatients v outpatients 81% v 63%, $p < 0.001$). The group admitted to hospital suffered more severe illness, and dehydration was found in 69% of these patients as compared with 26% of the outpatients ($p < 0.001$). The mean total duration of illness in the inpatients, outpatients, and 'telephone' patients, however, did not differ significantly (7.4, 8.7, and 6.8 days, respectively).

The occurrence of micro-organisms among patients with gastroenteritis and control patients is

shown in Table 1. Patients with gastroenteritis were divided into five main groups according to the enteropathogens detected: rotavirus (group 1), enteric adenoviruses (group 2), pathogenic bacteria (group 3), bacteria and virus (group 4), and no pathogens (group 5). Patients with other adenoviruses were excluded as details of their clinical characteristics in comparison with those of patients

with enteric adenoviruses have been published separately.⁹ The groups with other viruses and *Giardia lamblia* were too small for analysis. Thus 393 patients remained for clinical study. The age distribution of the different groups of patients was similar, except for children in the bacterial group, who were slightly older (Figure). Of the patients in groups 1 to 3 and 5, 10% were aged over 5 years. In the statistical analysis the rotavirus group was compared with each of the groups of patients with other enteropathogens in the same manner as Ellis *et al.*²

The rotavirus group was the largest and consisted of 168 children, of whom 65 were admitted to hospital and 103 were treated as outpatients. Of these 103 outpatients, 26 were 'telephone' patients. The clinical picture of rotavirus gastroenteritis was characterised by a high frequency of vomiting and fever and a low frequency of abdominal pain (Table 2). The onset of rotavirus illness was sudden. In 92 (55%) of the children vomiting was the initial symptom, preceding diarrhoea by between a few hours and 24 hours. Thirty seven patients had a simultaneous onset of diarrhoea and 39 had diarrhoea only as the first symptom. Apart from more pronounced vomiting there were no significant differences in clinical symptoms between inpatients and outpatients. Although patients admitted to

Table 1 Enteropathogens found in children with acute gastroenteritis and in control children. Values are No (%)

Group	Enteropathogens	Patients with gastroenteritis	Control patients
1	Rotavirus	168 (40)	4 (2)
2	Enteric adenoviruses	32 (8)*	0 (0)
3	Pathogenic bacteria	42 (10)†	6 (3)
4	Bacteria and virus	16 (4)‡	0 (0)
5	No pathogens	135 (32)	184 (92)
	Established adenoviruses	13 (3)	3 (2)
	Other viruses	6 (1)	1 (1)
	<i>Giardia lamblia</i>	4 (1)	2 (1)
Total		416	200

*Adenovirus types 40 (14 cases) and 41 (18).

†*Campylobacter jejuni* (15 cases), *Yersinia enterocolitica* (11), *Salmonella* species, (seven), *Shigella sonnei* (two), enteropathogenic *Escherichia coli* (three), and mixed bacteria (four).

‡Enteropathogenic *E. coli* and rotavirus (10 cases), enterotoxigenic *E. coli* and rotavirus (three), enteropathogenic *E. coli* and adenovirus (one), and *C. jejuni* and adenovirus (two).

Figure Age distribution of children with gastroenteritis caused by different enteropathogens.

Clinical features of acute gastroenteritis associated with rotavirus, enteric adenoviruses, and bacteria 735

hospital waited shorter time (mean 2.3 days) before coming to the hospital than outpatients (mean 3.3 days), these hospital admissions were more dehydrated and in a poorer general condition on arrival than the outpatients (Table 2). The mean

duration of rotavirus illness did not differ between the two groups (inpatients v outpatients 5.8 v 6.1 days).

A comparison of the clinical and biochemical features in group 1 and groups 2-5 is summarised in Tables 3-5. The patients with enteric adenoviruses had a lower rate of fever and less pronounced vomiting and fever than those with rotavirus (Table 3). Abdominal pain and bloody stools were highly significantly increased in children with pathogenic bacteria. The group with mixed bacterial and viral pathogens comprised comparatively few patients, but this group and the rotavirus group exhibited almost identical clinical patterns. Enteropathogenic *E. coli* in combination with rotavirus was the most common mixed infection and about 90% of the patients with paired serum specimens developed a significant seroresponse to rotavirus. The group with non-specific gastroenteritis had symptoms similar to those of the bacterial group, although the disease was milder and only 24% of these patients required admission to hospital. There were no

Table 2 Clinical characteristics of children with rotavirus gastroenteritis admitted to hospital and those who were not admitted to hospital. Values are No (%)

Clinical symptom	Patients admitted to hospital (n=65)	Patients not admitted to hospital (n=103)
Diarrhoea	61 (94)	103 (100)
Diarrhoea > 10 times daily	18 (28)	18 (17)
Vomiting	60 (92)	86 (83)
Vomiting > 5 times daily	33 (51)*	29 (28)
Fever	56 (86)	85 (83)
Fever > 39°C	23 (35)	48 (47)
Abdominal pain	13 (20)	18 (17)
Respiratory symptoms	21 (32)	35 (34)
Dehydration†	47 (72)**	31 (30)
Dehydration <5%†	19 (29)**	0 (0)

*p<0.01, **p<0.001.

†Excluding 26 'telephone' patients, who were not medically examined.

Table 3 Clinical features in 393 children with acute gastroenteritis in relation to enteropathogens detected in the stools. Values are No (%)

	Groups of patients				
	1 Rotavirus	2 Enteric adenovirus	3 Bacteria	4 Bacteria and virus	5 No pathogens
n=	168	32	42	16	135
Diarrhoea	164 (98)	31 (97)	42 (100)	16 (100)	132 (98)
Diarrhoea > 10 times daily	36 (21)	7 (22)	15 (36)	3 (19)	27 (20)
Vomiting	146 (87)	25 (78)	18 (43)***	15 (94)	72 (53)***
Vomiting > 5 times daily	62 (37)	3 (9)**	3 (7)***	5 (31)	19 (14)***
Fever	141 (84)	14 (44)***	29 (69)*	15 (94)	83 (61)***
Fever > 39°C	71 (42)	1 (3)***	18 (43)	7 (44)	45 (33)
Abdominal pain	31 (18)	8 (25)	21 (50)***	4 (25)	40 (30)*
Blood present in stools	2 (1)	1 (3)	17 (41)***	1 (6)	14 (10)***
Mucus present in stools	28 (17)	6 (19)	11 (26)	1 (6)	34 (25)
Respiratory symptoms	56 (33)	6 (19)	16 (38)	8 (50)	57 (42)
Admission to hospital	65 (39)	9 (28)	16 (38)	8 (50)	33 (24)*

*p<0.05, **p<0.01, ***p<0.001 (p values denote significant differences by χ^2 test between the rotavirus group and each of the other groups).

Table 4 Clinical course of gastroenteritis in children infected with different enteropathogens. Values are mean (SEM) duration of each symptom (days)

	Groups of patients				
	1 Rotavirus	2 Enteric adenovirus	3 Bacteria	4 Bacteria and virus	5 No pathogens
n=	168	32	42	16	135
Symptoms before hospital contact	2.9 (0.16)	5.3 (0.75)***	5.4 (0.59)***	3.0 (0.50)	3.9 (0.25)***
Diarrhoea	5.9 (0.28)	10.8 (1.71)***	14.1 (2.18)***	8.4 (1.70)**	8.0 (0.57)***
Vomiting	2.5 (0.10)	3.2 (0.80)	2.1 (0.34)*	2.1 (0.24)	2.1 (0.16)
Fever	2.2 (0.12)	2.4 (0.35)	3.3 (0.39)**	2.5 (0.40)	2.5 (0.16)
Hospital stay	2.4 (0.19)	3.6 (1.18)	3.6 (1.20)	2.6 (0.56)	2.8 (0.48)

*p<0.05, **p<0.01, ***p<0.001 (p values denote significant differences by Mann Whitney U test between the rotavirus group and each of the other groups).

Table 5 Clinical and biochemical findings in children with acute gastroenteritis investigated in hospital†. Values are No (%)

	Groups of patients				
	1 Rotavirus	2 Enteric adenovirus	3 Bacteria	4 Bacteria and virus	5 No pathogens
Dehydration	78/142 (55)	11/30 (37)	16/38 (42)	9/16 (56)	29/114 (25)***
Dehydration >5%	19/142 (13)	3/30 (10)	4/38 (10)	1/16 (6)	5/114 (4)*
General condition:					
moderately > severely ill	42/142 (30)	3/30 (10)*	11/38 (29)	4/16 (25)	18/114 (16)**
Intravenous fluid therapy	23/65 (35)	2/9 (22)	6/16 (38)	3/8 (38)	8/33 (24)
Erythrocyte sedimentation rate over 20 mm in the first hour	18/113 (16)	4/20 (20)	14/30 (47)***	3/10 (30)	17/76 (22)
Leucocyte particle count >12×10 ⁹ /l	7/116 (6)	7/21 (33)***	7/31 (23)**	1/11 (9)	15/84 (18)**

*p<0.05, **p<0.01, ***p<0.001 (p values denote significant differences by χ^2 test between the rotavirus group and each of the other groups).

†Excluding 'telephone' patients, who were not medically examined.

significant differences in the occurrence of respiratory symptoms between the groups. Interestingly, the lowest percentage (19%) was found in patients with enteric adenoviruses and the highest (79%) in children with established adenoviruses (p<0.001).⁹

Patients with rotavirus gastroenteritis sought medical advice earlier in the course of the disease (mean 2.9 days) than those with other infections (Table 4). Vomiting was the first symptom in 19%, 7%, 31%, and 17% of the children in groups 2–5, respectively. These figures differed significantly from the 55% recorded in the rotavirus group (p<0.001). The mean duration of diarrhoea was shortest in the group with rotavirus (5.9 days) and longest in the group with bacteria (14.1 days). In particular, children with *Y. enterocolitica* had prolonged diarrhoea for up to six weeks. There were no significant differences between the groups in the duration of fever and vomiting except for children with bacterial pathogens, in whom fever lasted longer and vomiting was less prolonged. The hospital stay was short in all the groups.

Patients with rotavirus and those with bacteria were more often regarded as moderately or severely ill than those with other pathogens (Table 5). Moderate to severe dehydration occurred in 8% of all patients, with no relation to age, and it was mostly isotonic. Out of 166 tested patients, four had hypernatraemia (sodium ≥ 150 mmol/l), two of whom were aged under 12 months, and one had hyponatraemia (sodium 128 mmol/l). The associated pathogens were rotavirus in four patients and adenovirus in one. Acidosis (base excess <−10.0 mmol/l) was diagnosed in nine of 23 tested patients, of whom eight had a rotavirus infection and one had non-specific gastroenteritis. A significant rise was found for erythrocyte sedimentation rate in group 3 and for white blood count in groups 2, 3, and 5 (Table 5).

One third of the patients admitted to hospital required intravenous fluid therapy because of dehydration or severe symptoms. The use of intravenous fluids did not differ significantly between the groups and was not related to age. Antibiotics were prescribed for six patients with bacterial gastroenteritis: two with *Salmonella* species, two with *Shigella sonnei*, and two with *Y. enterocolitica*. In addition, 61 patients with gastroenteritis received antibiotics because of tonsillitis and acute otitis media and four because of urinary tract infection.

There were no fatal outcomes during the study and complications occurred in few patients. Thirty five children (8%) had prolonged diarrhoea for more than 14 days. Temporary secondary lactose intolerance was found in 15 patients, four of whom had enteric adenoviruses. In addition, one child with enteric adenovirus did not tolerate gluten containing products for nine months after the onset of diarrhoea. Urinary tract infections, confirmed by positive culture, were found in four patients. A lumbar puncture was performed in 10 children on suspicion of meningitis, but all spinal fluid specimens were normal. No child had convulsions.

One 28 month old boy had renal symptoms with haematuria and slight proteinuria in association with a *Y. enterocolitica* type 03 infection, which was verified by culture and a significant seroresponse. He excreted the bacteria for 46 days and had diarrhoea and cramping abdominal pain at intervals for three months and microhaematuria for four months. Another 18 month old boy had reactive anaemia (haemoglobin 5.9 g/dl) in connection with a yersinia infection. He had had no previous disposing disease and on treatment with blood transfusions and co-trimoxazole he made a complete recovery. Intussusception occurred in association with *Y. enterocolitica* in one patient and non-specific gastroenteritis in another patient.

Discussion

This study has shown that the clinical pictures of gastroenteritis with rotavirus, enteric adenoviruses, and pathogenic bacteria each exhibit features that enable a presumptive diagnosis to be made. In addition, the pathogens display seasonal characteristics, such as the winter peaks of rotavirus and the autumnal occurrence of bacteria,⁷ which can further support a specific diagnosis. We consider that the reliability of our findings is strengthened by the fact that all the children were interviewed, examined, treated, and followed up by the same clinician.

Rotavirus has been recognised as the most important diarrhoeal agent in children admitted to hospital,^{1-3 5 6} whereas its role in children not admitted to hospital has not been completely elucidated. In the present study rotavirus was found to be the most commonly identified agent in both inpatients (45%) and outpatients (38%). The disease in ambulatory patients was milder, mainly on account of less pronounced vomiting, but apart from this the clinical picture, with the sudden onset of vomiting, the high frequency of fever and dehydration, and the low occurrence of abdominal pain and bloody stools, was strikingly similar in both groups of patients. The severity of the illness varied but was not related to age or sex. Rotavirus diarrhoea lasted for a median of five days irrespective of whether the patients were treated in hospital or as outpatients. This remarkable consistency in the constellation of clinical symptoms and in the course of the illness enabled us to identify a typical 'rotavirus syndrome'. In contrast to Lewis *et al*,⁵ we did not find that this syndrome was significantly associated with respiratory symptoms.

In spite of the use of electron microscopy, solid phase immune electron microscopy, and ELISA, we only detected rotavirus particles in one of the 200 control children. In addition, three control children developed significant seroresponses to rotavirus. In several studies throughout the world similar low percentages of rotavirus carriers among controls have been reported.^{1 2 4} Recent investigations in Europe have, however, revealed a very high incidence (24-48%) of asymptomatic rotavirus infections among children admitted to hospital.¹⁰ Also among outpatients Gurwith *et al* observed that only 65% of the children with rotavirus had gastrointestinal symptoms.¹¹ These conflicting results are difficult to explain, but there may have been differences in the immunity of the population, the ages of the children, the conditions of hygiene, or the extent of virus circulation. There is no information about the electrophoretotypes or neutralising serotypes of rotavirus in these studies; perhaps there were certain

strains of low virulence circulating at the time of the investigations.

In comparison with rotavirus, enteric adenoviruses caused a milder disease with less intense vomiting, fever, and dehydration, which meant that the parents sought medical advice later in the course of the disease. The predominant symptom was persistent diarrhoea, and adenovirus 41 particularly caused long lasting symptoms (mean 12.2 days), even in comparison with adenovirus 40 (mean 8.6 days).⁹ This protracted course of enteric adenovirus gastroenteritis has also been described by others (Zissis G, Lambert JP, Fonteyne JL. Enteric adenoviruses and diarrhoea. Abstract No 27. International Symposium of Recent Advances in Enteric Infections. Brügge, Belgium, 1981), but milder symptoms of shorter duration have also been reported.¹² The rare occurrence of respiratory symptoms in association with enteric adenoviruses, in contrast to the high frequency in association with established adenoviruses, has also been observed by other authors.¹³ It seems that these new enteric adenovirus types are restricted to the intestinal tract. Attempts to detect the viruses in nasopharyngeal secretions have not been successful.¹⁴

The occurrence of abdominal pain, macroscopic blood in the stools, prolonged diarrhoeal symptoms, a raised erythrocyte sedimentation rate, and leucocytosis was strongly suggestive of a bacterial diagnosis. In contrast to rotavirus, the initial symptom in a high proportion (81%) of the children with bacterial infection was diarrhoea. Vomiting was uncommon and when it did occur it was of low intensity and of short duration. The presence of mucus in the stools was not typically associated with bacterial infection but occurred in similar frequencies in all groups of patients, in accordance with other reports.^{3 4 6}

The only clinical difference between children simultaneously infected with virus and bacteria compared with those infected with rotavirus alone was a prolongation of the diarrhoeal symptoms. Ellis *et al* observed an even longer duration of diarrhoea in association with mixed infections,² and this discrepancy may be related to the types of bacterial and viral strains involved. The most common combination of dual pathogens in the present study was enteropathogenic *E. coli* and rotavirus (10 of 16 infections) and most of the children with this combination developed a significant seroresponse to rotavirus. In contrast to Carr *et al*¹⁵ we did not observe an increased severity of illness in children infected with these two pathogens combined.

The group with non-specific gastroenteritis may form a heterogeneous group and certainly includes

several different enteropathogenic agents. The clinical comparison between these patients and those with a defined pathogen must therefore be made with caution. The clinical characteristics most resembled those in bacterial infection, although the course was milder, the diarrhoea was of shorter duration, and abdominal pain and bloody stools were less common findings. These features may suggest that both new viruses and new bacterial agents not yet discovered are included in this group. There could hardly have been any 'missed' cases of rotavirus and adenoviruses as we used a broad panel of sensitive techniques to detect these pathogens in parallel with serologic diagnostics. Norwalk virus¹⁶ and other small viruses not detectable by electron microscopy, however, and viruses only identifiable by tissue culture, could be responsible for some of these unknown infections. Among bacterial pathogens *Aeromonas hydrophila* and *Plesiomonas shigelloides*¹⁷ were not screened for, but these pathogens have up to now only rarely been encountered in sporadic infantile gastroenteritis. This group of unidentified enteric agents merits further studies and new approaches in developing diagnostic techniques.

Paediatric gastroenteritis in developed countries is nowadays considered to be a fairly mild and self-limiting disease,^{2 3 18} which was also confirmed in this study. Hypernatraemia and severe dehydration were extremely rare, in contrast to the situation 20 years ago.^{8 19} This may be explained by the improved management of rehydration with the widely used standardised oral rehydration solutions instead of high solute fluids. Prolonged diarrhoea and temporary secondary lactose intolerance were the most common sequelae. An important complication in association with yersinia enteritis was glomerulonephritis. This has been documented in other studies²⁰ but has not previously been described in children. This complication may indicate that antibiotics should be prescribed more often for yersinia enteritis.

In conclusion, the comparative analysis of this investigation has shown that rotavirus, enteric adenoviruses, and bacteria are associated with different clinical patterns. An experienced clinician would be able to arrive at a presumptive diagnosis through a detailed case history, physical examination, routine laboratory tests, and knowledge of the seasonal occurrence of different pathogens. A rapid preliminary diagnosis of the aetiological agent is of importance in many respects. Early treatment with antibiotics of any septic bacterial infections can then be begun, steps can be taken for prevention of nosocomial and family transmission, and, not least, the parents can be given information about the expected course of

the disease. This presumptive diagnosis can then lead to an adequate choice of relevant methods for confirming the causative agent.

This work was supported by grants from the First of May Flower Annual Campaign for Children's Health, the Swedish Society of Medical Sciences, and the 'Förenade Liv' Mutual Group Life Insurance Company, Stockholm, Sweden.

References

- Kapikian AZ, Kim HW, Wyatt RG, *et al.* Human reovirus-like agent as the major pathogen associated with "winter" gastroenteritis in hospitalized infants and young children. *N Engl J Med* 1976;294:965-72.
- Ellis ME, Watson B, Mandal BK, *et al.* Micro-organisms in gastroenteritis. *Arch Dis Child* 1984;59:848-55.
- Rodriguez WJ, Kim HK, Arrobo JO, *et al.* Clinical features of acute gastroenteritis associated with human reovirus-like agent in infants and young children. *J Pediatr* 1977;91:188-93.
- Hieber JP, Shelton S, Nelson JD, Leon J, Mohs E. Comparison of human rotavirus disease in tropical and temperate settings. *Am J Dis Child* 1978;132:853-8.
- Lewis HM, Parry JV, Davies HA, *et al.* A year's experience of the rotavirus syndrome and its association with respiratory illness. *Arch Dis Child* 1979;54:339-46.
- Mäki M. A prospective clinical study of rotavirus diarrhoea in young children. *Acta Paediatr Scand* 1981;70:107-13.
- Uhnoo I, Wadell G, Svensson L, Olding-Stenkvis E, Ekwall E, Möllby R. Aetiology and epidemiology of acute gastroenteritis in Swedish children. *J Infect* 1986. (In press.)
- Ironside AG, Tuxford AF, Heyworth B. A survey of infantile gastroenteritis. *Br Med J* 1970;iii:20-4.
- Uhnoo I, Wadell G, Svensson L, Johansson ME. Importance of enteric adenoviruses 40 and 41 in acute gastroenteritis in infants and young children. *J Clin Microbiol* 1984;20:365-72.
- Champsaur H, Henry-Amar M, Goldszmidt D, *et al.* Rotavirus carriage, asymptomatic infection, and disease in the first two years of life. II. Serological response. *J Infect Dis* 1984;149:675-82.
- Gurwith M, Wenman W, Hinde D, Feltham S, Greenberg H. A prospective study of rotavirus infection in infants and young children. *J Infect Dis* 1981;144:218-24.
- Flewett TH, Bryden AS, Davies H, Morris CA. Epidemic viral enteritis in a long-stay children's ward. *Lancet* 1975;i:4-5.
- Brandt CD, Kim HW, Rodriguez WJ, *et al.* Adenoviruses and pediatric gastroenteritis. *J Infect Dis* 1985;151:437-43.
- Petric M, Krajden S, Dowbina N, Middleton PJ. Enteric adenoviruses. *Lancet* 1982;i:1074-5.
- Carr ME, McKendrick DGW, Spyridakis T. The clinical features of infantile gastroenteritis due to rotavirus. *Scand J Infect Dis* 1976;8:241-2.
- Greenberg HB, Valdesuso J, Yolken RH, *et al.* Role of Norwalk virus in outbreaks of nonbacterial gastroenteritis. *J Infect Dis* 1979;139:564-8.
- Holmberg SD, Farmer JJ. *Aeromonas hydrophila* and *Plesiomonas shigelloides* as causes of intestinal infections. *Rev Infect Dis* 1984;6:633-9.
- Ellis ME, Watson B, Mandal BK, Dunbar EM, Mokashi A. Contemporary gastroenteritis of infancy: clinical features and prehospital management. *Br Med J* 1984;288:521-3.
- Tripp JH, Wilmers MJ, Wharton BA. Gastroenteritis: a continuing problem of child health in Britain. *Lancet* 1977;ii:233-6.
- Friedberg M, Denneberg T, Brun C, Larsen JH, Larsen S. Glomerulonephritis in infections with *Yersinia enterocolitica* 0-serotype 3. *Acta Med Scand* 1981;209:103-10.

Correspondence to Dr I Uhnoo, Department of Infectious Diseases, University Hospital, S-751 85 Uppsala, Sweden.

Received 1 April 1986