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EPIDEMIC DYSENTERY CAUSED BY THE SHIGA BACILLUS IN A SOUTHERN INDIAN VILLAGE

V.I. MATHAN, P. BHAT 1 C.R. KAPADIA 2 J. PONNIAH 3 AND S.J. BAKER 4

The Wellcome Research Unit, Christian Medical College Hospital, Vellore 632 004, India. 1 Department of Microbiology, St Johns Medical College, Bangalore, India. 2 Veterans Administration Hospital, West Haven, Conn. USA. 3 Department of Pathology, Miraj Medical College, Miraj, India. 4 St. Boniface General Hospital, Winnipeg, Canada

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Abstract

Multi-drug resistant Shigella dysenteriae type 1 caused an epidemic of dysentery in a village in southern India. The epidemic started as a common source outbreak, through the piped water supply of the village with subsequent person-to-person spread. Although the attack rate was high, with nearly half the children under age five being affected, the case fatality rate was only about one per 100. The role of early maintenance of hydration and nutrition in the field situation in managing diarrhoeal epidemics is emphasized.

Key words: Shigella dysenteriae; Dysentery, Bacillary; Epidemiology.

Introduction

Diarrhoeal diseases are endemic to rural areas in India and occasionally assume epidemic proportions. Epidemics of diarrhoea associated with Salmonella infection, food poisoning, fecal contamination of unprotected drinking water sources and tropical sprue (1-3) have been reported earlier from southern India. This paper reports an epidemic of acute dysentery in a southern Indian village, caused by a multi-drug resistant strain of Shiga bacillus, which has been considered an unusual enteric pathogen in this part of the world (4). The epidemic had an explosive outbreak and a high attack rate, and apparently was associated with an allegedly ‘protected’ water supply in the village.

Materials and methods

Field surveillance of the North Arcot District of Tamil Nadu is maintained by the Unit for Detection of Diarrhoeal Epidemics. An unusual number of diarrhoea cases in a village was reported on 8th November 1972, and a detailed house-to-house survey was completed in 3 days. The village was kept under close surveillance for 3 months, until the epidemic had subsided. The village was followed up at 3 monthly intervals for the next 2 years.

Fecal samples were obtained from 59 patients and 70 age-matched controls. Stool samples were obtained on three occasions during the first two weeks of study (Nov. 11-25). Patients who had been symptomatic for less than 4 days were sampled and were matched by controls either from the same household or from adjacent households of similar age (±5 years, over 12 years of age, and ±1 year in younger age groups). Samples were obtained in the early morning and divided immediately into two portions, one of which was kept on ice and the other at ambient temperature. The samples reached the laboratory within 3 hours of collection. A variety of media were used for isolation of pathogens, as detailed elsewhere (4,5).

The portion of the stool sample kept at ambient temperature was examined for parasites, with direct wet smears of bloody mucoid stools and concentration methods. A presumptive coliform count was done on drinking water samples, and 5-10 liters of drinking water were filtered through 3 μm millipore filters. The filters then were cultured for pathogens.

A field clinic in the village offered therapy for the patients and, in addition, 14 patients who agreed to hospitalization were admitted to a metabolic ward for studies of intestinal absorptive function (6).

Results

The village and its water supply

ER (population 2,050), an agricultural village 60 km northeast of Vellore, was naturally divided
into 10 sections (Fig I) by the layout of streets. Eight sections (I-VIII) received water through street taps from a common overhead tank, to which water was pumped from a shallow well 20 meters from the edge of the village. The well had a 1-meter parapet wall around it without a cemented shoulder, and had steps to the bottom. Four meters from this well was another shallow unprotected well, used for irrigating the fields and for bathing. Water was pumped to the overhead tank daily from 7 to 8 am, and the supply was exhausted by about 11 am. Fifteen of the more wealthy households had individual water connections from street lines. All households stored water for the day's use, and supplemented it from private wells in backyards and some street wells. Section IX, where the village school was situated, and Section X, economically the most backward, had no piped water supply, but did have several shallow wells from which water was obtained. There were no festivals or common meals in the village immediately prior to the epidemic. The school, which did not provide any food to the pupils, was closed from November 6th, due to the epidemic.

Section VI of the village (attack rate 6.0/100 population). In the subsequent 2 weeks, 217 new cases occurred, the highest number on November 1st (21 cases). During this period, cases occurred more or less uniformly in all sections of the village sharing the common water supply, except in Section II (Table I). By the middle of December, the epidemic had subsided.

The overall attack rate was 26.6 per hundred (546 patients). The attack rate in preschool children was significantly higher than in other age groups, with adults having the lowest attack rate (Table II). Of the village's 497 households, cases occurred in 278, but 14 out of 15 houses with household water connection had cases. Sections IX and X, which did not share the common water supply, had the lowest attack rates (Fig I), and significant numbers of cases occurred later during the course of the epidemic (Table I).

Bacteriological studies

Shigella dysenteriae type 1 (Shiga bacillus), resistant to penicillin, streptomycin, tetracycline, chloramphenicol, erythromycin and ampicillin, but sensitive to neomycin, kanamycin and gentamicin, was isolated from 43 of the 59 stool samples from patients, but was not found in any of the 70 controls. Sulphamezathine sensitivity was not tested. In three of the patients, in addition to the

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Fig. 2—Epidemic curve of diarrhoea in ER. Number of new cases of diarrhoea and dysentery per week, starting with the last week of September is shown. The cases in September, early October and the latter half of December comprise the expected background incidence of diarrhoea.

Fig. 1—Outline map of village ER. The dotted lines outline the street sections (I to X). The solid line shows the water distribution system with street taps. T — overhead tank, MW — main well from which water is pumped to the tank. FW — field well, W — wells supplying water to sections IX and X. The figures show final attack rates per hundred population in each street block. Section VII, with an attack rate of 35, obtains water from the taps in adjacent Section VI. Sections IX and X did not share the common water supply.

The epidemic

During the last week of October (25-31), 31 new cases of dysentery occurred, of which 16 were in children (Fig. 2). These were mainly in
TABLE I—WEEKLY ATTACK RATES (PER 100) IN DIFFERENT SECTIONS OF VILLAGE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>0</td>
<td>6.7</td>
<td>8.9</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>II</td>
<td>0</td>
<td>0.6</td>
<td>2.5</td>
<td>5.1</td>
<td>8.1</td>
</tr>
<tr>
<td>III</td>
<td>0.3</td>
<td>7.1</td>
<td>9.9</td>
<td>3.1</td>
<td>5.9</td>
</tr>
<tr>
<td>IV</td>
<td>2.3</td>
<td>4.3</td>
<td>9.3</td>
<td>4.6</td>
<td>1.7</td>
</tr>
<tr>
<td>V</td>
<td>2.1</td>
<td>4.0</td>
<td>2.9</td>
<td>5.5</td>
<td>5.2</td>
</tr>
<tr>
<td>VI</td>
<td>6.0</td>
<td>11.2</td>
<td>4.4</td>
<td>5.5</td>
<td>2.3</td>
</tr>
<tr>
<td>VII</td>
<td>0.9</td>
<td>5.3</td>
<td>4.7</td>
<td>3.0</td>
<td>2.0</td>
</tr>
<tr>
<td>VIII</td>
<td>1.2</td>
<td>7.1</td>
<td>5.5</td>
<td>4.9</td>
<td>3.2</td>
</tr>
<tr>
<td>IX</td>
<td>0.6</td>
<td>2.3</td>
<td>2.3</td>
<td>3.6</td>
<td>2.5</td>
</tr>
<tr>
<td>X</td>
<td>0</td>
<td>0.6</td>
<td>1.2</td>
<td>0.6</td>
<td>0.9</td>
</tr>
</tbody>
</table>

primary organism, *S. boydi* 9 and 12 and *S. flexneri* 4 also were isolated. Moreover, *S. boydi* 9 and *S. flexneri* 4 also were isolated from one each of the controls. There was no significant difference in the prevalence of stool parasites between patients and controls.

TABLE II—AGE-SPECIFIC ATTACK RATES PER HUNDRED

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>All cases</th>
<th>Secondary and subsidiary cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4.9</td>
<td>49.6</td>
<td>25.0</td>
</tr>
<tr>
<td>5 – 11.9</td>
<td>38.1</td>
<td>17.5</td>
</tr>
<tr>
<td>12 – 17.9</td>
<td>23.2</td>
<td>10.8</td>
</tr>
<tr>
<td>18 +</td>
<td>18.2</td>
<td>9.6</td>
</tr>
</tbody>
</table>

*First case in household*

Clinical features and management

The detailed clinical features were analyzed in 248 patients who attended the field clinic. Of these, 89.4% passed small mucoid stools mixed with blood, with the majority complaining of crampy lower abdominal pain and tenesmus. The other 10.6% had a history of diarrhoea only, without blood and mucus. Only a quarter of the patients had a history of fever associated with the onset of symptoms, although 10 of 14 patients admitted for detailed study were febrile. One child developed a hemolytic-uremic syndrome and was hospitalized. Fourteen other patients were hospitalized for detailed studies. *S. dysenteriae* type 1 was cultured from seven of them after hospitalization, 2-to-10 days after onset of symptoms. There was leukocytosis with a shift to the left in the differential count in ten. Only in one instance were *Entameba histolytica* cysts seen in the stool. Nutritional status indicators, such as hemoglobin, serum albumin, serum vitamin B12, folic acid and serum iron concentrations, were not significantly different from those in random samples of the population. All 14 had normal absorption of fat and vitamin B12, while 4 of the 14 had low urinary xylose excretion after 5 gm orally.

Only less than half of those affected in the epidemic attended the field clinic for therapy. All patients attending the clinic were given detailed instruction to ensure adequate intake of fluid and nutrients, and were given a mixture containing kaolin for symptomatic relief. Moreover, 126 patients were given appropriate doses of sulphonamethazine for 4-7 days. Twenty-three of these and a further 16, mainly children under age 10, were given therapy with neomycin in appropriate dosage during the latter half of November.
differences in the mean and median duration of symptoms among those attending and not attending the clinic suggests that, in general, it was those with more severe illness who came for treatment (Table III). The average duration prior to seeking therapy was about 5 days. It also is clear from this table that therapy with sulphamezathine or neomycin was given to individuals who, based on the total duration, had more severe illness. About 10% of those who did not attend the clinic went to a town about 10 km away, and, in general, were given one of a variety of antibiotics (usually capsules containing chloromycetin and streptomycin) for 1 or 2 days.

In addition to instructions regarding the maintenance of fluid and nutrient intake given at the clinic, public health nurses and doctors of the team visited all households daily, and ensured that adequate fluid and food intake was maintained by all patients, including those not voluntarily coming to the clinic.

TABLE III—MEAN DURATION OF SYMPTOMS IN DAYS

<table>
<thead>
<tr>
<th>Age group (in years)</th>
<th>0 – 4.9</th>
<th>5 – 11.9</th>
<th>12 – 17.9</th>
<th>18 +</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cases</td>
<td>14.2 (10)*</td>
<td>9.2 (7)</td>
<td>9.9 (7)</td>
<td>10.8 (8)</td>
</tr>
<tr>
<td>Non-clinic</td>
<td>9.7 (9)</td>
<td>8.0 (7)</td>
<td>8.6 (7)</td>
<td>9.7 (7)</td>
</tr>
<tr>
<td>Clinic</td>
<td>17.1 (14)</td>
<td>10.7 (8)</td>
<td>9.4 (8)</td>
<td>12.3 (10)</td>
</tr>
<tr>
<td>Sulphna</td>
<td>21.3</td>
<td>12.8</td>
<td>11.9</td>
<td>15.2</td>
</tr>
<tr>
<td>Neomycin</td>
<td>29.8</td>
<td>12.9</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kaolin</td>
<td>12.4</td>
<td>10.0</td>
<td>8.8</td>
<td>11.0</td>
</tr>
<tr>
<td>Duration prior to attending clinic</td>
<td>5.5</td>
<td>5.2</td>
<td>4.0</td>
<td>5.3</td>
</tr>
</tbody>
</table>

*Figures in parenthesis indicate median duration. Mean duration of symptoms of age groups 0-4.9 and 18+ significantly longer (p < 0.01) in those attending clinics than in those not attending clinics. Mean duration in patients 0-4.9 years age treated with sulphamezathine and neomycin significantly longer than untreated and kaolin treated groups (p < 0.01).

Mortality

Six of the affected individuals—4 children under age 5 and two adults over 65—died due to diarrhoea subsequent to November 15th. None of these patients had attended the clinic for therapy or was willing to be brought to the hospital. Two of the deaths occurred within 48 hours of onset of diarrhoea, and were related to fluid and electrolyte losses. The other deaths (3 children, 1 adult) occurred 6-to-22 days after the onset of diarrhoea, and it was difficult to determine the exact causes of death. A further 7 deaths due to causes unrelated to the epidemic occurred in the village from November to January.

After the subsidence of the epidemic there was neither a secondary outbreak nor a significant number of cases of dysentery during the next 2 years.

Discussion

The isolation of a single strain of multi-drug resistant S. dysenteriae type 1 from 43 of the 59 patients whose stools were cultured, and the clinical picture, identify this epidemic as one of shiga bacillary dysentery. This organism has been considered a rare pathogen in this part of India, and accounted for only about 1% of the bacterial isolates in a longitudinal study (4). This epidemic is reminiscent of epidemics reported from Central America (7-10) and Bangladesh (11,12). After 1972, the frequency of isolation of this organism in hospitalized patients at Vellore increased, and incidences of children with the hemolytic-uremic syndrome as a sequelae of Shiga dysentery have been reported (13). Further epidemics due to S. dysenteriae type 1 in southern Indian villages suggested, in fact, that an unrecognized pandemic due to this organism may have occurred during the 1970's in southern India (14).

The evolution of the epidemic in ER suggests that the well supplying water to the village became fecally contaminated in the last week of October, leading to the explosive outbreak in the first half of November. The distribution of the epidemic paralleling the water supply, the high household attack rates in houses with individual water connection, and the sparing of the section of the village without the common water, all suggest that the water distribution system served as the

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Epidemic shigellosis

vehicle for distribution of the epidemic. However, *Shigellae* could not be cultured from the water supply, possibly due to the prior heavy chlorination. Why did the heavy chlorination on November 9th with significant residual chlorine a week later fail to abort the epidemic, as observed in Bangladesh (12)? The houses are crowded together in Tamil Nadu villages, and the backyards and streets are used for defecation especially by children who were affected in the epidemic. The perpetuation of the epidemic after chlorination of the water supply and its spread to areas of the village not sharing the water supply is, therefore, likely to have been due to secondary person-to-person spread.

Shiga dysentery is considered a severe infection with high morbidity and mortality. In the Central American pandemic there was a four-fold or greater increase in deaths due to dysentery (7). The antibiotic resistance pattern of the organism isolated in the present epidemic suggests that it was at least as virulent as the one identified in Central America (10). Clinically, the patients had a fairly severe infection, with crampy, bloody diarrhoea and fever in a high proportion (10 of 14 hospitalized patients) and leukocytosis with a shift to the left. Despite this, mortality was low (death-to-case ratio of 1 to 91), and on follow-up there were no significant sequelae. The low morbidity and mortality could be due to a lower virulence of the organisms or to better nutrition of the population compared to that in other reports. However, it is tempting to hypothesize that the low mortality in this epidemic was related to the early and good maintenance of hydration and nutrition, which was ensured by the field team. Initially, there was considerable resistance to drinking water, as this was against the ingrained cultural habit of treating all diarrhoea by starvation and withholding of water. However, firm and patient persuasion was successful. Since the patients who did not attend the clinic also were persuaded to drink adequate water and eat food in their homes, we do not have data to confirm that maintenance of water and food intake made a significant difference. Comparisons with mortality figures in other epidemics (7,10) would support the hypothesis that early and adequate maintenance of hydration and nutrition was a significant factor in reducing mortality.

*Shigellae*, especially the Shiga bacillus, has been a significant cause of diarrhoea mortality and morbidity in tropical developing countries in the '70's, and southern India was no exception to this. However, the data presented here show that even this severe infection could be managed in the field with maintenance of hydration and symptomatic measures, with only a small proportion of patients possibly needing specific antibiotic therapy.

**Acknowledgements**

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Correspondence and reprint requests should be addressed to: Prof. V.I. Mathan.

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