

Public Health Significance of Rotavirus Gastroenteritis

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ABSTRACT

Background: Rotavirus is a type of virus that lacks the membranous layer (envelope); belonging to the family *Reoviridae*. Rotavirus derived its name from its characteristic appearance of a wheel like structure, as revealed by electron microscopy. This virus has been known for many years as the causative agent of inflamed stomach and intestines among children, which can spread by fecal-oral transmission and clearly exhibit itself with abdominal pains, increased urge to vomit, headache, feeling of discomfort, fever and severe diarrhea. Therefore, treatment of the infection is primarily targeted. There are two vaccines; Rotarix and RotaTaq, have been developed to stop the viral infection. The administration of *Lactobacillus* spp. is an additional treatment regime, to reduce the time of the severe stooling.

Objectives: To review and compare the public health consequences of rotavirus gastroenteritis around various communities.

Methodology: Detailed analysis of existing literature on rotavirus gastroenteritis together information on its structure, symptoms, pathology and treatment have been generated. All the relevant articles published from 1962 to 2020 were looked over numerous sources like Google Scholar, Medline, PubMed, Research Gate, Science Direct, Scopus and Web of Science.

Results: After due review, it was observed that rotavirus associated gastritis is most prevalent amongst infants and young children who come in contact with reservoirs and contaminants. The replacement of fluids and electrolytes remain the mainstay for its treatment. Vaccination, along with improved personal hygiene both for the infected and their care givers are the most important methods of preventing the transmission of rotavirus infections. It was also seen that some parts of Africa contributes the highest occurrence rates of rotavirus infections and that infant mortalities recorded annually that are associated with diarrhea are mostly caused by rotavirus.

Conclusion: Rotavirus is the most isolated agent associated with inflamed stomach and intestine (gastroenteritis) in infants and young children with high fatality rate, and it is very contagious. Frequent washing of hands must be encouraged especially in schools, day care facilities, hospitals and other public places to reduce its spread.

Keywords

Causative agent, Envelope, Gastroenteritis, Microscopy, Rotavirus, Reoviridae.

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INTRODUCTION

Rotavirus has been known for more than 20 years as the causative agent of gastroenteritis in younger children and in some adults. It is majorly transmitted from person to person via faecal-oral transmission, and usually exhibit itself with fever, increased urge to vomit, feeling of discomfort, headache, abdominal pain and severe stooling. Infection can also present itself without symptoms. In

adults (with compromised immunity), the infection can vary from mild-without symptoms to severe and continuous manifestation¹. Diarrhoea caused by Rotavirus is ubiquitous and unlike diarrhoea as a result of bacteria, is not more prevalent in settings with poor hygiene, water quality and sanitation. In third world countries, rotavirus has

a fatality rate of about 2% among children². This fatality rate is higher in areas without good access to health care.

In 2013, the virus was reported to cause over 200,000 deaths worldwide³. The virus is highly communicable, shed in the stool at high concentration. The incubation period is about three days. Rotavirus peaks in cool, dry seasons in temperate climates but become less pronounced in tropical settings¹. Several rotavirus vaccines are licensed and commercially available, all of which have been found to be effective in randomized controlled trials. There are currently two varieties of oral rotavirus vaccines that are commercially marketed internationally, viz: the (RV1) Rotarix® (given in two doses) and the pentavalent (RV5) RotaTeq® (given in three doses)⁴. The doses for both vaccines are separated by four weeks interval and starting as in children who are 6 weeks old. The efficiency of the vaccine vary from 50% to >90% against severe rotavirus diarrhoea, with moderate efficacy in countries with higher mortality. But due to high rates of the infection in these countries, the number of serious cases stopped by vaccination is high regardless of this lower efficacy. Another oral vaccine (ROTAVAC®), was licenced in India more recently, after it was found to be effective in a clinical trial. Hitherto, this vaccine variant is administered in three consecutive doses to infants who present in registered centres for vaccination⁵.

The vaccine has decreased severe gastroenteritis burden as a result of rotavirus infection in many countries and rotavirus mortality. WHO in 2013, endorsed the proper use of the vaccines and reiterated the inclusion of the rotavirus vaccines in all national immunization protocols, especially those in rotavirus endemic areas that account for the majority of infant mortality globally, such as south Asia and Africa, as part of diarrhoea treatment and preventive measures. This review is intend to shed light on the public health significance of rotavirus types, pathogenesis, symptoms, treatment, and prevention.

Rotavirus Gastroenteritis

Ruth Bishop first detected the enteric virus in 1973, when she analysed the intestinal content of some children diagnosed with gastroenteritis (inflamed stomach and intestines). Rotavirus contain double-stranded RNA covered by a capsid. Eleven segments of the RNA are found within the core. Six protein components of the virus

known as the viral proteins (VP) which constitute the viral capsid, and the viral non-structural proteins which are encoded by the rotavirus RNA specifically. The core is however covered by an inner capsid that consists chiefly of special viral proteins (VP6) which make up the primary group antigens of the virus^{6,7}, and includes the epitopes which are detected easily. The protein shell of the virus, otherwise known as the capsid is basically composed of the VP4 proteins, which are said to contribute to the phenomenal spiky appearance of the wheel shaped virus and VP7. Trypsin cleaves this viral protein *in vitro* into two; the VP5 and VP8, both play a central role in the viral cellular attachment. The double-layered structure as seen under the electron microscopy (negative-stain) is as a result of the inner and outer capsids^{8,9}. The virus derives its name from Latin word; rota, meaning "wheel" (Fig 1). Under the microscope, the viral particle measures about 70 nm in diameter¹⁰.

Rotaviruses are the major identified aetiological agents of acute gastroenteritis in children and in some animals, accounting for most of the diarrhoea related infections in children within their first 5 years of life¹¹ (Fig 2). Gastrointestinal disease caused by the virus is particularly prevalent in third-world countries¹¹. In 1973, Ruth Bishop and friends discovered the virus by investigation with electron micrograph which revealed small particles nodes in central nervous system¹², and responsible for more than 65% of in-patient cases of acute to severe passage of watery stools, with or without vomiting in children¹³. It is usually described as most common virus isolated from the small intestines of children with gastroenteritis¹⁴. Certain viruses with similar morphological characteristics have been identified over the years in the intestinal tissues of mice with excessive stooling¹⁵. Its clinical importance has been underestimated, most especially in developing countries. Apart from the impact on humans, the virus is also a pathogen of animals¹⁶.

According to Jonesteller *et al.*¹⁷, this virus is the most observed cause of inflamed stomach and intestines in children across the globe, reported to be responsible for over 120,000 fatalities in the year 2016 alone and it was reported that more than 70% of the cases were observed in some parts of Africa. Rotavirus causes over 200 million mild cases of the infection which require simple remedy which can be taken care of at home and about 20 million

cases which require hospital attention¹⁸. Evidence from recent studies shows that Rotavirus associated deaths has greatly reduced from over 500,000 deaths as reported in 2000 to approximately 200,000 deaths in the year 2013. However, a greater percentage of the reported rotavirus associated deaths especially in children younger than 5 years of age was observed in Africa and some parts of Asia. India and Nigeria alike, accounted for over 20% and 10% of the total mortalities, respectively¹⁸. About six countries in the world contributes more than half of the global death rates of the virus, including Nigeria, India, Congo, China, Ethiopia, and Pakistan¹⁹.

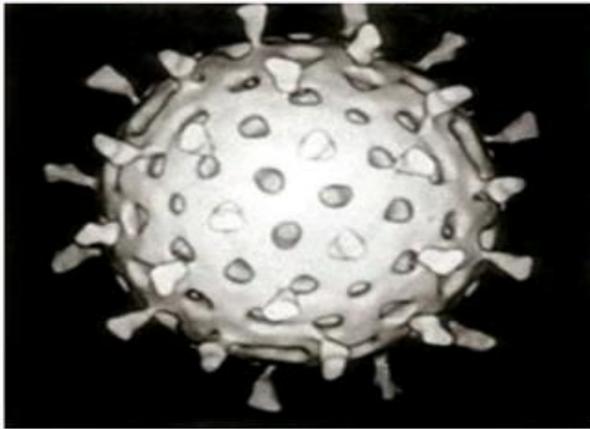


Figure 1. Rotavirus Micrograph (Computer-aided reconstruction). (Adapted from Patton (1995)¹¹.

Types of Rotavirus

Rotavirus has ten species A-J²⁰. Most of the human related rotavirus infections are associated with the Rotavirus A group. However, the species of rotavirus labelled in the groups ranging from A to E predominantly cause animal related diseases. Those in the groups E and H alike, cause infections in pigs, while the species of D, F and G are mainly the causal agents of diseases in birds. Those in the group I have been isolated in infected cats and group J species of rotavirus have only been seen in bats²¹. Rotavirus A, the species implicated in human rotavirus cases are different strains which are generally called serotypes²².

Mode of Transmission and Pathogenesis

The virus is passed down via the fecal-oral transmission by being in contact with contaminated surfaces, hands and objects²³⁻²⁵. After taking in food and water, the virus is ingested into to the small intestine where they bind and

then find their way into the cells of the intestinal lining through direct entry and endocytosis and then forms an endosome. The outer layer of the virus disrupt the endosome membrane, causing calcium imbalance^{26, 27}. After the cytolitic replication in the colon of the infected individual, infective virus particles move to cause infections in certain areas in the small intestine of the individual or the infective viral particles may be passed down to the rectum from where it is prepared for exit movement in the form of faeces. It is estimated that the viral load in about one gram of faeces passed out by an infected person contain well over 1,000 viral particles⁷. The concentration of the virus found in the stool of an infected adult may be more. A study by Vollet *et al.*, (1979), it was reported that shedding was far lower in travellers' diarrhoea. Adults with no symptoms can shed the virus in very low quantities²⁸.

Rotavirus infection changes the small intestinal function which results in diarrhoea. There are limited knowledge as to the methods by which the virus initiates diarrhoea. Some studies involving human mucosal sample evaluation had been done in recent past to enable scientists gather more information about the pathogenesis of rotavirus infections. The existing information describes certain concepts which are important in having fundamental understanding in the activities leading to atrophy, inflammation and microvilli changes^{26,29,30}.



Figure 2. Rotaviruses isolated in faecal samples of a child. (Adapted from Dennehy (2000)²⁵.

Symptoms

Infection with the virus usually occurs in infants and young children who are aged 6 months to about 3 years.

Infections in new born and very serious cases in children below 6 months have been previously reported^{31, 32}. The classic presentation of the infection which cut across all ages is high temperature and vomiting for about 3 days, then diarrhoea³³. The diarrhoea may be as frequent as up to 20 bowel movements per day, and it could be more severe with active vomiting accompanied. It can cause serious and eventually lead to life-threatening dehydration if left untreated. Stool examination from affected patients shows that it is generally free of faecal leucocytes. Children who are re-infected with the virus are often not seriously affected than those newly infected³⁴. In healthy adults, the infection may be symptomatic.

Risk Factors

Rotavirus infections are frequently seen amongst infants and young children and based on the virulence and ease of rotavirus transmission from person to person, care givers, staff of day care facilities and close relatives who are in close proximity with the infected children are at higher risk of contracting the infection. Adults who are care givers for children in other facilities other than the aforementioned are also at high risk of getting infected. In the USA, the risk of the virus is reported to be highest in winter and spring. The main method of spread is through hand to mouth after touching contaminated surfaces, and/or hands with stool of a person infected. Infection with rotavirus is highly transmissible from the initial period of the disease, well before the presentation diarrhoea down to about 10 days after most patients recovers from all visible symptoms²⁵.

Treatment and Prevention

Symptom relief and normal body function restoration is the primary goal of treatment of rotavirus infections. The treatment involves initial dehydration treatment using oral rehydration therapy, which is used extensively on infected children in most developing countries. Most adults can be treated by drinking fluids. Also, the administration of *Lactobacillus* spp. is an additional treatment regime, used to mitigate the period of stooling^{35, 36}. In controlling diarrhoea volume, drugs like codeine, loperamide, and diphenoxylate can be helpful, although seldom used in children⁷. Also, bismuth subsalicylate, is effective in treating the symptoms of the infection rotavirus³⁷. In cases where symptoms become difficult to control and the patient

becomes seriously dehydrated, hospital admission and intravenous fluid administration may be very necessary.

To reduce the spread of the virus and thus the infection, frequent hand washing is encouraged, especially after the use of the toilet. Children's diaper should be changed regularly and disposed correctly, exposure and faecal-oral spread must be avoided. Also avoid contact with sick children especially those diagnosed with the virus and contaminated food and water. Since, over 40% of the virus placed on human fingers survive for up to one hour, hand washing is very important to prevent it³⁸. It is very important to isolate patients diagnosed with the virus infection, because of continuous stooling and shedding of low concentrations of virus³⁹. The use of gloves, gowns should be in place as well as rigorous hand washing in caring for infected individuals⁴⁰. Sattar *et al.*, (1986), reported that the virus best survives in conditions with low relative humidity on surfaces which are non-porous and at ambient temperature⁴¹. Phenol based disinfective agents are reported to have very low or no effect against rotavirus, instead sodium dichloroisocyanurate or sodium hypochlorite disinfectants are recommended. Ethanol (70%), also has high effect in inactivating the virus and environmental spread prevention^{39, 42}.

Furthermore, two vaccines available in prevention of the virus infection are:

RotaTeq (RV5): This vaccine is administered by mouth in three divided doses, the first at about 8 weeks after birth, the next dose at 4 months and the final dose at 6 months of age, respectively. It is not approved for use in children older than 6 months of age or adults.

Rotarix (RV1): Administered in two divided doses, the first is administered at 2 months and the last dose given at 4 months of age⁴.

The vaccine can produce a very rare side effect called intussusception, which is characterized with a small section of the intestine folding back on itself, which can lead to intestinal obstruction or blockage that can be life threatening if left unattended. There is likely a repeat of intussusception after taking the vaccine in children who have had it before taking it. The Food and Drug Administration (FDA) for this reason endorses that vaccination is not administered to children who have previously suffered from intussusception⁴³.

CONCLUSION

Rotavirus is the most isolated agent associated with inflamed stomach and intestine (gastroenteritis) in infants and young children, with high fatality rate, and it is very contagious. It is therefore recommended that there be a serious awareness concerning it; especially in developing countries and public health education on how to prevent and control the spread of the virus. Frequent washing of hands must be encouraged especially in schools, day care facilities, hospitals and other public places.

CONFLICTS OF INTEREST

None.

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None.

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LIST OF ABBREVIATIONS

| | |
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| FDA | Food and Drug Administration |
| USA | United States of America |
| WHO | World Health Organisation |

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