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Salmonella-A Review on Epidemiology, Pathogenesis and Prevention of Disease

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Summary

Salmonella is an important pathogen for both humans and animals. Although the organism has been intensively considered during the last century, much remains to be well-read regarding this pathogen. Salmonella species are gram-negative bacilli that are responsible for significant morbidity and mortality in both developing and developed nations. They are responsible for a wide variety of diseases, including enteric fever or typhoid fever (S. Typhi and S. Paratyphi), as well as a range of clinical syndromes, including diarrheal illness caused by a group of bacteria known as non-typhoid Salmonella (NTS). This review summarizes briefly, new and significant insights concerning Epidemiology, pathology and preventive measures of the disease.

Introduction

Salmonella is a rod-shaped, Gram-negative facultative anaerobe that belongs to the family Enterobacteriaceae (Barlow and Hall 2002). S. enterica is a worldwide importance causing as many as 1.3 billion cases of disease annually (Ochman and Groisman 1994; Fierer and Guiney 2001.) The Salmonella enteric species include about 2600 diverse serotypes, most of which scause a wide range of food and water-borne diseases ranging from self-limiting gastroenteritis to typhoid fever in both humans and animals. Moreover, some serotypes are restricted to a few animal species, whereas other serotypes are able to infect plants as well as cold and warm-blooded animals (Velge et al., 2012). Salmonella is large and closely related population of medically important pathogens (Lin and Cheng 2007). S. enteric species are typically orally acquired pathogens that cause one of four major syndromes: enteric fever (typhoid), enterocolitis/diarrhea, bacteremia and chronic asymptomatic carriage. The disease manifestation depends on both host susceptibility and the infectious S. enteric serovar (Fierer and Guiney 2001). In humans, serovars Typhi, Paratyphi and Sendai cause enteric fever, while most serovars cause enterocolitis/diarrhea (Bryan et al. 2007). Salmonella and Campylobacter are the most frequently isolated foodborne pathogens, and are predominantly found in poultry, eggs and dairy products (Silva et al.2011). Some of other food sources that are involved in the transmission of Salmonella include fresh fruits and vegetables (Pui et al. 2011; Shu et al. 2015). Typhoid fever is a global problem, and is most common among children, especially in areas of Asia and Africa that lack clean water and adequate sanitation, and is also an important travel-associated disease (Connor and Schwartz 2005). S. Typhi is an exclusively human pathogen causing a bacteremic disease that, unlike many other Gram-negative bacteremias, does not typically manifest with neutrophilia or septic shock (Tsolis et al. 2008). The widespread appearance of antimicrobial-resistant strains have limited treatment options (Arjyal et al. 2011; Beeching and Parry 2011). Relapse and chronic asymptomatic fecal carriage may complicate the illness (Monack et al 2004; Monack DM 2011). Mortality usually results from intestinal perforation and peritonitis or from a severe toxic encephalopathy associated with myocarditis and hemodynamic shock (Parry et al. 2002). Infections with non-typhoidal Salmonella (NTS) serovars, such as S. enteric serovar Typhimurium and S. Enteriditis, also cause a significant disease burden, with an estimated 93.8 million cases worldwide and 155,000 deaths each year (Feasey et al. 2012). The variations in the clinical features of infection with this intracellular pathogen relate to differences in the interaction between different Salmonella serovars and the host (Hanna et al. 2012).

Causative Agent

The genus Salmonella is composed of two distinct species: Salmonella bongori and Salmonella enterica, the latter being divided into six subspecies. (Hanna et al. 2012) enterica, salamae, arizonae, diarizonae, houtenae, and indica (Guibourdenche et al. 2010). The agglutinating properties of the somatic O, flagellar H, and capsular Vi antigens are used to differentiate more than 2600 serologically distinct Salmonella (Guibourdenche et al. 2010, Velge et al., 2012). About 90% of the genes in S. Typhi and S. Typhimurium serovars are identical (McClelland et al. 2001). The 10% of genes that differ include virulence factors, which determine their pathogenic potential (Sabbagh et al. 2010). Strains belonging to S. enterica subsp. enterica cause approximately 99% of Salmonella infections in humans and warm-blooded animals (McClelland et al. 2001, Velge et al., 2012).

Classification of Salmonella

The antigenic classification system of various Salmonella serovars used today has accumulated from many years of studies on antibody interactions with surface antigens of Salmonella organisms established by Kauffman and White almost a century ago. All antigenic formulae of recognized Salmonella serotypes are listed in a document called the Kauffmann-White scheme.(Popoff et al. 2001; Lin and Cheng 2007). Kauffmann-White scheme classifies Salmonella according to three major antigenic determinants composed of flagellar H antigens, somatic O antigens and virulence (Vi) capsular K antigens. This was adopted by the International Association of Microbiologists in 1934. Agglutination by antibodies specific for the various O antigens is employed to group Salmonellae into the 6 serogroups: A, B, C1, C2, D and E. For instance, S. Paratyphi A, B, C and S. Typhi express O antigens of serogroups A, B, C1 and D, respectively (Pui et al. 2011). The WHO Collaborating Centre for Reference and Research on Salmonella at the Pasteur Institute, Paris, France is responsible for updating the scheme. Every year newly recognized serovars are reported in the journal Research in Microbiology by Popoff et al. (Popoff et al. 2004). Currently, the nomenclature system used at the CDC for the genus Salmonella is based on recommendations from the WHO Collaborating Centre. According to the CDC system, the genus Salmonella contains two species, S. enterica, the type species, For those designated by their antigenic formulae, the subspecies name is written in Roman letters (not italicized) followed by their antigenic formulae, including O (somatic) antigens, H (flagellar) antigens (phase 1), and H antigens (phase 2, if present). A colon is used between each antigen, e.g., Salmonella serotype II 39:z10:z6 (Lin and Cheng 2007).

Epidemiology

Typhoid cases are stable with low numbers in developed countries, but nontyphoidal salmonellosis has increased worldwide. Typhoid fever usually causes mortality in 5 to 30% of typhoid-infected individual in the developing world. The World Health Organization (WHO) estimates 16 to 17 million cases occur annually, resulting in about 600,000 deaths. The mortality rates differ from region to region, but can be as high as 5 to 7% despite the use of appropriate antibiotic treatment. On the other hand, nontyphoidal cases account for 1.3 billion cases with 3 million deaths. Typhoid fever is endemic throughout Africa and Asia as well as persists in the Middle East, some eastern and southern European countries and central and South America. In the US and most of Europe, typhoid is predominantly a disease of the returning traveler (Pui et al. 2011). Enteric fever is endemic in many regions of the African and Asian continents as well as countries such as in Europe, South and Central America, and the Middle East. The incidence of enteric fever in the USA and some European countries is low, with the total number of Salmonella cases being less than 10 per 100,000 annually. Most of the cases reported in these countries are related to travel, with the disease being imported by foreigners or travelers returning from Africa, India or Pakistan (Molbak et al. 2002; Cooke et al. 2007). Many Asian countries, including China, India, Vietnam, Pakistan and Indonesia, have high incidence rates of enteric fever, exceeding 100 cases per 100,000 populations annually. Compared to other Asian countries, Pakistan and India have the highest incidence rates of 451.7 cases and 214.2 cases per 100,000 population, respectively (Ochiai et al.2008). In endemic regions, enteric fever occurs more frequently in infants, preschool and school-age children. (Mweu & English 2008; Shu et al. 2015).

Transmission and Pathogenesis

S. Typhi is transmitted through contaminated food and water, following ingestion, the bacteria spread from the intestine via blood to the intestinal lymph nodes, liver, and spleen where they multiply. Significant morbidity and mortality is associated with this disease possibly affecting over 90 million people globally each year (Majowicz et al. 2010). The risk of acquiring typhoid fever is increased among clinical microbiologists and travelers to regions where the disease is endemic (Levine et al. 2004; Kaur and Jain 2012). This route of infection is shared with non-typhoidal Salmonella serovars (NTS), the causative agents of gastroenteritis. Gastroenteritis is characterised by a rapid onset after a short incubation period (12-72h) and a brief duration (<10 days), while, typhoid fever has a considerably longer incubation period (median of 5 to 9 days) and longer duration of symptoms (fever persists for approximately three weeks). Also, gastroenteritis is an infection that remains localized to the intestine and mesenteric lymph nodes in immunocompetent patients, whereas typhoid fever is a systemic infection during which S.Typhi colonizes the liver, spleen and bone marrow in addition to the intestine and the mesenteric lymph nodes (Santos et al. 2001; Tsolis et al, 1999; Manuela et al. 2008).

Prevention

Even though estimation swings greatly due to a lack of standard diagnosis and reporting, between 200 million and 1.3 billion cases of intestinal disease, including 3 million deaths due to non-typhoidal Salmonella are expected to occur each year worldwide (WHO 2005). Like typhoid, the frequency of intestinal disease caused by non-typhoidal Salmonella species is highest in the developing world, but is also of significant importance in developed countries (Bryan et al. 2007). Contaminated water or food is the most important transmission route of enteric fever. At present, preventive measures for enteric fever concentrate on access to safe water and food, proper sanitation and the use of typhoid vaccines. Ensuring the safety of water for consumption is the main goal for the eradication of possible transmission routes of typhoid Salmonella as well as NTS. This important measure has been successfully accomplished in developed countries, such as in Europe and the USA, but not in developing and underdeveloped countries (Clasen et al. 2007). Besides water, Salmonella spp. can be found in a variety of foods, predominantly in poultry, eggs and dairy products. Proper handling and cooking of food are measures proposed to wipe out the bacterial contamination of food. In many countries, food irradiation has been greatly supported due to its effectiveness in reducing the risk of food contamination. Approved by several public health agencies, including the WHO and CDC, the technology of food irradiation is only moderately utilized in some areas in Europe and the USA because of the risk of radioactivity (Osterholm and Norgan 2004). Vaccination is an effective measure in preventing enteric fever. Inactive parenteral and oral live attenuated vaccines are the two types of vaccine currently approved for the prevention of enteric fever. However, these licensed vaccines are limited to infants and they are not effective in preventing infections caused by S. Paratyphi and NTS (Lin et al. 2001; Shu et al. 2015).

Conclusion

Salmonella infection leftovers a difficult public health consternation globally. There are two vaccines have been approved in favor of the prevention for enteric fever, but till date no licensed vaccines are presented for S. Paratyphi and non-typhoid Salmonella infection.

Conflict of Interest: There is no conflict of interest.

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