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Original Research

Characterization of Staphylococcal Food Poisoning

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Abstract:

Food-borne diseases are of major concern worldwide. To date, around 250 different food-borne diseases have been described, and bacteria are the causative agents of two thirds of food-borne disease outbreaks. Among the predominant bacteria involved in these diseases, Staphylococcus aureus is a leading cause of gastroenteritis resulting from the consumption of contaminated food. Staphylococcal food poisoning is due to the absorption of staphylococcal enterotoxins preformed in the food. Staphylococcus aureus produces a wide variety of toxins including staphylococcal enterotoxins (SEs; SEA to SEE, SEG to SEI, SER to SET) with demonstrated emetic activity, and staphylococcal- like (SE) proteins, which are not emetic in a primate model (SE/L and SE/Q) or have yet to be tested (SE/J, SE/K, SE/M to SE/P, SE/U, SE/U2 and SE/V). SES and SE/s have been traditionally subdivided into classical (SEA to SEE) and new (SEG to SE/U2) types. All possess superantigenic activity and are encoded by accessory genetic elements, including plasmids, prophages, pathogenicity islands, vSa genomic islands, or by genes located next to the staphylococcal cassette chromosome (SCC) implicated in methicillin resistance.

Keywords: Staphylococcus aureus, Food-borne diseases , Toxin

Introduction:

Food-borne diseases (FBD) are defined by the World Health Organization as "diseases of infectious or toxic nature caused by, or thought to be caused by the consumption of food or water". [1] More than 250 FBDs have been described. Symptoms vary widely, depending on the etiological agents. Diarrhea and vomiting are the most common. Among FBDs, food-borne infections are caused by many different disease-causing pathogens that can contaminate foods, while food-borne poisoning is caused by poisonous chemicals, or other harmful substances that are present in food.[2] In many countries, national health care organizations record FBD outbreaks, defined as the occurrence of two or more cases of a similar illness resulting from the ingestion of a common food.[3] True incidence of FBDs is difficult to evaluate, as many cases remain undeclared.[4] Foodborne infections affect both men and women, all age groups, all seasons, and both rural and urban areas and they can occur in sporadic or epidemic. Foodborne infections affect roughly 20% of people in industrialized countries each year [2]. Staphylococcus aureus infections range from mild skin infections to life- threatening ones; such as bacteremia, endocarditis, necrotizing pneumonia, toxic shock syndrome and food poisoning [5]. The ingestion of food containing pre-formed Staphylococcus enterotoxins causes staphylococcal food poisoning [6]. There are five serologically distinct enterotoxins (A, B, C, D. and E), with enterotoxin a being the most common cause of food poisoning outbreaks [7]. It is estimated that 30- 80% of the human population are carriers of Staph. aureus, with 50% of them carrying food poisoning variants. As a result, unsanitary food handling must be regarded a major source of Staph. aureus contamination [8]. Food handlers or other surfaces, such as processing equipment, are usually where Staphylococcus aureus gets access to the foods. Although bacteria can be found on the skin of animals, water, soil, and other surfaces, bacteria from food handlers and other human sources are thought to be the most major contributors to food poisoning [3,4].

Baked desserts, such as cream-filled pastries, cream pies, and chocolate éclairs, meat and meat products, potatoes, tuna, chicken, turkey, ready-to-eat salads, eggs, poultry, milk, and dairy products are regularly contaminated by Staphylococcus enterotoxins (SES) [7,9].

The diagnosis of Staphylococcus aureus is based performing tests with colonies. Coagulase, hemolysins, and thermostable deoxyribonuclease tests are all commonly performed [8]. Recent genetic advances have made it possible to identify and characterize clinical isolates of Staphylococcus aureus in a reliable and timely manner [2,6].

Staphylococcus Aureus and Staphylococcal Food Poisoning:

Staphylococcal food poisoning (SFP) is an intoxication that results from the consumption of foods containing sufficient amounts of one (or more) preformed enterotoxin [7,8]. Symptoms of SFP have a rapid onset (2–8 h), and include nausea, violent vomiting, abdominal cramping, with or without diarrhea [9,10]. The disease is usually self-limiting and typically resolves within 24–48 h after onset. [11] Occasionally it can be severe enough to warrant hospitalization, particularly when infants, elderly or debilitated people are concerned [12]

Staphylococcus aureus strains can be classified into biotypes according to their human or animal origin. Devriese (1984) developed a biotype schema, including six different biotypes (human, non-B-hemolytic human, avian, bovine, ovine, and nonspecific), based on biochemi- cal characteristics. [13]

Staphylococcus aureus is an important pathogen due to a combination of toxin-mediated virulence, invasiveness, and antibiotic resistance. This bacterium is a significant cause of nosocomial infections, as well as community-acquired diseases. The spectrum of staphylococcal infections ranges from pimples and furuncles to toxic shock syndrome and sepsis, most of which depend on numerous virulence factors.

On the other hand, some infections, such as staphylococcal food poisoning, rely on one single type of virulence factor: the SEs. The symptoms of staphylococcal food poisoning are abdominal cramps, nausea, vomiting, sometimes followed by diarrhea (never diarrhea alone). The onset of symptoms is rapid (from 30 min to 8 h) and usually spontaneous remission is observed after 24 h. [14]

Food handlers carrying enterotoxin-producing Staph. aureus in their noses or on their hands are regarded as the main source of food contamination, via manual contact or through respiratory secretions. In fact, Staph. aureus is a common commensal of the skin and mucosal membranes of humans, with estimates of 20- 30% for persistent and 60% for intermittent colonization [15]. Because Staph. aureus does not compete well with indigenous microbiota in raw foods, contamination is mainly associated with improper handling of cooked or processed foods, followed by storage under conditions which allow growth of Staph.

aureus and production of the enterotoxin(s). However, Staph. aureus is also present in food animals, and dairy cattle, sheep and goats, particularly if affected by subclinical mastitis, are likely contaminants of milk [7]. Air, dust, and food contact surfaces can also serve as vehicles in the transfer of S. aureus to foods.

Staphylococcus aureus Enterotoxins and Staphylococcal Enterotoxin Activities:

The Staph. aureus enterotoxins (SEs) are potent gastrointestinal exotoxins synthesized by Staph. aureus throughout the logarithmic phase of growth or during the transition from the exponential to the stationary phase [16,17,18,19,20]. They are active in high nanogram to low microgram quantities [21], and are resistant to conditions (heat treatment, low pH) that easily destroy the bacteria that produce them, and to proteolytic enzymes, hence retaining their activity in the digestive tract after ingestion.

The SES belong to a family of the so-called pyrogenic toxins originating from staphylococcus and streptococcus species. Pyrogenic toxins include SES. TSST, exfoliatins A and B and streptococcus pyrogenic toxins. These toxins share some structure, function and sequence similarities. They have phylogenetic relationships as we. Until recently, SEs were discovered in studies of Staph. aureus strains implicated in FBD outbreaks, and they were classified in distinct serological types. Thus, SEA to E and SEH have been clearly demonstrated as being capable of more or less potent emetic activity. More recently, increasing data resulting from partial or complete genome sequence analyses have allowed the identification of several new SE types. [5] These new SEs were first identified on the basis of sequence and structural similarities with existing SEs. There is experimental evidence for their superantigenic in vitro and/or in vivo activities, but rarely their emetic activity. Although pyrogenic toxins are involved in distinct pathologies, they have common biological activities: they are pyrogenic, and they cause immunosuppression and nonspecific T-cell proliferation. [8] These activities are referred to as superantigen activity. Besides these common features, some toxins are able to cause other symptoms. Among superantigens, only SEs have emetic activity. Superantigen and emetic activity of the SEs are two separate functions localized on separate domains of the protein. Nevertheless, a high correlation exists between these activities since, in most cases, genetic mutations resulting in a loss of superantigen activity result also in a loss of emetic activity.

Foods Involved in Staphylococcal Poisoning:

In all cases of staphylococcal food poisoning, the foodstuff or one of the ingredients, was contaminated with an SE-producing Staph. aureus strain and was exposed, at least for a while, to temperatures that allow S. aureus growth. Most of the time the foodstuff reaches this temper-ature because of a failure in the refrigeration process, or because a growth-permissive temperature is required during processing (e.g., cheese making). [16] Many different foods can be a good growth medium for Staph. aureus, and have been implicated in staphylococcal food poisoning, including milk and cream, cream-filled pastries, butter, ham, cheeses, sausages, canned meat, salads, cooked meals and sandwich fillings. [17]

The foods that are most often involved in staphylococcal food poisoning differ widely from one country to another. [18] In the United Kingdom, for example, 53% of the staphylococcal food poisonings reported between 1969 and 1990 were due to meat products, meat-based dishes, and especially ham; 22% of the cases were due to poultry, and poultry-based meals, 8% were due to milk products, 7% to fish and shellfish and 3.5% to eggs. In France, things are different. Among the staphylococcal food poisonings reported in a two-year period, among the cases in which the food involved had been identified, milk products and especially cheeses were responsible for 32% of the cases, meats for 22%, sausages and pies for 15%, fish and seafood for 11%, eggs and egg products for 11% and poultry for 9.5% . In the United States, among the staphylococcal food poisoning cases reported between 1975 and 1982, 36% were due to red meat, 12.3% to salads, 11.3% to poultry, 5.1% to pastries and only 1.4% to milk products and sea-foods. [19] In 17.1% of the cases, the food involved was unknown. Thus, the origins of staphylococcal food poisoning differ widely among countries; this may be due to differences in the consumption and food habits in each of the countries. In France, for example, the consumption of raw milk cheeses is much higher than in Anglo-Saxon countries. [20] This may explain the relative importance of milk products involved in staphylococcal food poisoning in France [21].

Conclusion:

Staphylococcus aureus is a Gram-positive bacterium that is the leading cause of food poisoning throughout the world. All Staph aureus isolates contained one or more enterotoxin-forming genes which give the bacteria the ability to cause food poisoning to the consumers. Enterotoxin type A and type C were considered the main enterotoxins and may be responsible for occurrence of food poisoning outbreaks. The organism is ubiquitous in distribution, and is found in the healthy and diseased humans as well as animals. The environmental contamination of foods is an important cause of staphylococcal food poisoning. It is emphasized that food handlers must be closely monitored during the preparation of food. Attempts should be made to develop a simple, sensitive and low-cost technique to detect staphylococcal enterotoxins in food, and clinical specimens of the patients.

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