Prevention of foodborne listeriosis

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ABSTRACT

Listeria monocytogenes is a foodborne pathogen that can cause serious invasive illness, mainly in certain well-defined high-risk groups, including elderly and immunocompromised patients, pregnant women, newborns and infants. L. monocytogenes primarily causes abortion, septicemia or meningitis. Contaminated meats (such as hot dogs, delicatessen meats and paté), dairy products and seafood have all been implicated in outbreaks of listeriosis. The public health importance of listeriosis is not always recognized, particularly because listeriosis is a relatively rare disease compared with other common foodborne illnesses such as salmonellosis or botulism. However, because of its high case fatality rate, listeriosis ranks among the most frequent causes of death due to foodborne illness, ranking second after salmonellosis. L. monocytogenes emerged as an important foodborne pathogen in the latter part of the 20th century. Extensive work has been performed in many countries during the last decade to prevent outbreaks and decrease the incidence of listeriosis. An important reduction occurred in listeriosis incidence in some of these countries during the 90s, suggesting a relationship between preventive measures and incidence decrease of human listeriosis.

KEY WORDS: Dairy products, food safety, listeriosis, outbreaks

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INTRODUCTION

Listeria monocytogenes is a worldwide zoonotic, widely distributed in nature, found in a variety of animal or birds feces and in the soils. Listeriosis is a high-risk disease for pregnant women and vulnerable ages of life. The Work Group of the World Health Organization, in their recent review of listeriosis, consider that even though it is a zoonosis, it is transmitted by the foodborne route to humans. Although the soils are the main source of L. monocytogenes, human transmission is conceived from the environment by animals and contaminated food products during processing. Hence, it must be considered as an environmental bacterium.

MILK-RELATED OUTBREAKS

The first proof that milk products could be responsible for listeriosis outbreaks was corroborated by Fleming et al. They studied an outbreak on 49 cases, seven of them in the fetus or in infants and 42 in immunocompromised adults. The source of infection was the consumption of pasteurized whole milk or with 2% fat. Although it was not possible to isolate the germ from milk cultures, it was known that there had been bovine listeriosis in the cattle that supplied milk (four cases of listeric encephalitis were diagnosed). The symptoms (meningitis, septicemia or abortion) were variable and depended on the patient's age or immune vulnerability. The mortality rate was 29%.

With the aim to identify the spot of outbreaks, an investigation was undertaken on a pasteurization plant. As it was clean and well handled, no source of contamination could have developed during this process, although a bacterium was isolated in 15 of 124 samples (12%) taken before the pasteurization. The bacteria could not be isolated from pasteurized milk. However, the vet reported about four cases of listeriosis in bovines. As a consequence, a strong epidemiological association was found between the consumption of whole or low-fat milk and developing the disease.

Another outbreak due to pasteurized chocolate milk was described by Dalton et al., which occurred at a picnic in Illinois on July 9, 1994. After receiving complaints about the taste and quality of the chocolate milk, its leftovers were taken for analysis. Of the 60 people who had drunk the chocolate milk, 45 (75%) informed having symptoms in the next 7 days after consumption. The mean age for those who developed the disease was 31 (range 3-79) and for those who did not was 24 (range 4-69). Among all of them, 19 (51%) were female and 26 (58%) were male. Four patients aged 1, 7, 49 and 77 years old had to be hospitalized for 8 days and there were no fatalities.

The results from the bacterial genome analysis were exactly the same as that found in the patient's feces, in three additional patients identified by surveillance, in the suspicious milk chocolate and in the drain pipe from the dairy plant, indicating that Listeria from the chocolate milk caused the outbreak.

In Europe, so far there have been 400 cases of listeriosis and nearly 60 deaths as a result of the investigated outbreaks. Approximately 0.2-0.8 listeriosis cases occur annually out of 100,000 people in developed countries. This means that 1600-8400...
cases occur in Europe each year, with 320-2500 deaths. This wide incidence range might be due to notification differences or because of outbreaks, which may rapidly increase the number of cases. The number of cases related to outbreaks informed in Europe between 1991 and 2001 was 2065.[9]

CHEESE-RELATED OUTBREAKS

In outbreaks and sporadic cases of listeriosis studied by Lundgren et al.,[10] the main sources of contamination were dairy products: from raw unpasteurized milk to butter made with pasteurized milk, including several types of cheese made with non-pasteurized milk (soft cheese, farmer’s cheese, blue cheese and Brie cheese).

Linnan et al.[6] described an outbreak associated with Mexican cheese in southern California, which affected 93 pregnant women or their children and 49 non-pregnant patients. The analysis of this outbreak showed that the most frequent cause for cheese contamination was using raw milk for its production.

Boggs et al.[7] refer to an outbreak that took place between November 2000 and January 2001 in North Carolina, related to home-made Mexican cheese with non-pasteurized milk. Most of the patients had eaten unlabeled Mexican cheese, bought at local markets or from street vendors. Listeria isolation in patients, raw milk and cheese was analyzed using pulsed-field gel electrophoresis, which proved the genome identity. Of the 12 identified cases, 11 were women of 21 years as the mean age (range 18-38) and one was an immunocompromised 70-year-old male. Ten of the women were pregnant and L. monocytogenes infection caused five dead fetuses, three premature babies and two infected newborns. The 11th woman was 5 months post-partum when she checked into a local hospital with meningitis caused by L. monocytogenes and no previous medical condition.

Every case was confirmed by the lab except one. The infection was more frequent in patients than in controls after consuming any cheese bought from street vendors, Mexican cheese or hot dogs. Several members of the Mexican immigrant community elaborated Mexican-style cheese with raw milk at their homes. Inspectors found unlabeled Mexican cheese in three local Latin stores in Winston Salem. The owners of two local dairy shops (Forsyth County) distributed raw milk from where samples were extracted for analysis. Listeria isolations were found in nine patients, three cheese samples from local stores, a cheese sample from a patient’s home and a raw milk sample from a dairy shop. An investigation took place at a dairy farm to determine the contamination source for L. monocytogenes. They took milk samples of 49 dairy cows and from the milk storage tank. The result was negative for L. monocytogenes. Therefore, it was inferred that the cows were not infected and the contamination might have been environmental. As a result of this outbreak, North Carolina’s health authorities forbade raw milk sale at dairy farms, educated businesses not to sell non-regulated milk products and recommended to emphasize the community’s knowledge on the dangers associated with consuming cheese made with non-pasteurized milk during pregnancy.[7]

Another L. monocytogenes foodborne outbreak was described by Büla et al.[8] They studied 57 cases occurring in west Switzerland related to soft swiss cheese consumption and, strikingly, most of the cases were in young and healthy people. Two L. monocytogenes strains were isolated from patients, soft swiss cheese and factories. From 1983 to 1987, a total of 122 cases occurred: 65 in newborn babies and pregnant women and 57 in men and non-pregnant women (which were used for this study). All of the patients included in the study were over 18 years old, from whom blood and cerebrospinal fluid isolations were taken. They were then categorized according to their illness: patients with bacteremia and positive blood cultures (12 cases, 21%), patients with meningitis and positive cerebrospinal fluid cultures (23 cases, 40%) and patients with meningoencephalitis and positive cerebrospinal fluid and/or blood cultures (22 cases, 39%). Bacteremia patients were older (mean age 75) than those with meningitis (69 years old) and meningoencephalitis (55 years old). All of them showed fever, 46% had digestive symptoms such as vomits and diarrhea and 83% of the meningitis and 59% of the meningoencephalitis patients suffered from mental alterations. Of the 27 survivors, nine (30%) developed neurological consequences: one due to meningitis and eight for meningoencephalitis. The mortality rate was 32% global (25% for bacteremia, 30% meningitis and 36% for meningoencephalitis).[6] Azadian et al.[9] published a meningitis case caused by Listeria related to cheese consumption made from goat milk. Pini and Gilbert[10] examined 222 Britannic and imported cheese samples and discovered that 10% contained L. monocytogenes in amounts less than 10^2-10^5 colony forming units (CFUs) per gram.

Goulet et al.,[11] studied the data obtained from food monitoring carried out by the Agriculture Ministry of France. Ready to consume products were sampled, 5,809 in 1993-1994 and 6,147 in 1995-1996. They found that meat products (19.8%) and seafood (10.4%) were more likely to be contaminated than dairy products (4.7%) and ready cooked salads (4.5%). Nevertheless, dairy products were found to be more frequently contaminated with higher doses than other products, 1.8% were contaminated with >10^5 CFU/g compared to 0.3, 0.5 and 1.1% from salads, seafood and meat products, respectively. During 1993-1994 and 1995-1996, they observed a decrease in contaminated products proportion, with >10^5 CFU/g compared to those with <10^5 CFU/g.[11]

Ho et al.[12] implied that cheese and raw vegetables are responsible for listeriosis.[12] Of all food products, cheese is more frequently contaminated and above all, contaminated with white mould. These types of cheese have a higher pH than most of the others within late maturation stages and consequently are more likely to be contaminated by this bacterium. Several studies show that up to 10% of these cheese are contaminated with L. monocytogenes and that the pathogen’s prevalence varies according to the type of cheese. In soft and semi-soft cheese, the water activity is greater than in hard cheese, allowing the bacteria to thrive.
OTHER PRODUCTS LINKED TO OUTBREAKS

Besides dairy products, other foods were found to be responsible for L. monocytogenes to spread, causing outbreaks. In 1981, in Canada, an outbreak linked to coleslaw intake occurred, affecting seven adults, 34 newborns and pregnant women. During the study carried out by Schlech et al.,[13] they were able to access a sample of the coleslaw that one of the infected patients kept on his refrigerator. The results of the analysis showed the presence of the same strain of L. monocytogenes in the salad and in the sample of blood extracted from the patient. The rest of the food kept in the refrigerator turned out to test negative for L. monocytogenes.[13]

The high point of the outbreak occurred during the summer of 1981, but there had been an increase in the amount of cases during the summer of 1980. Cases of pregnant women showed acute fever followed by spontaneous miscarriage in five cases, fetal death in four cases, premature births or term births with serious disease in 23 cases and births of healthy children in two cases. The rate of mortality in children was 27%. The age range for men and non-pregnant women was from 21 to 81 years, which included six men and one woman. From the seven cases, six showed meningitis and one showed pneumonia and sepsis. Mortality of meningitis cases was 33%.[13]

Pregnancy was taken as an important risk factor, but could not explain the total risk, and in men and non-pregnant women cases with meningitis, they were all immunologically normal, which suggested the importance of other factors of susceptibility not yet defined. The implicated foods were coleslaw and radish. Sixty percent of the cases remembered to have eaten coleslaw. This was made by a local producer with cabbages and carrots bought at different wholesalers and farmers from the region. The source responsible for the outbreak was identified as coleslaw that came from a farm that cultivated cabbages and also had a flock of sheep. Two of the sheep had died from listeriosis, one in 1979 and the other in March 1981. The cabbages grew in fields that used fertilizer with sheep’s fresh manure. After the harvest in October, cold preservation (4°C) of the cabbages took place, kept as stock during winter and the beginning of spring. The unusual practices by the farm (the fertilizer with sheep’s manure) and the cold protection during a long period of time before distributing it to the wholesalers allowed a little inoculum of L. monocytogenes to proliferate or cause the death of the competitive microorganisms. Therefore, this study allowed to define raw vegetables, especially coleslaw, as the source of the infection for human listeriosis cases produced in Canada.[13]

A study by McLaughlin et al.[14] points at paté as a possible cause that helped to raise the incidence of listeriosis between 1987 and 1989 in the United Kingdom and in the Irish Republic. Between 1967 and 1982, 100 annual cases of listeriosis were reported in England, Wales and North Ireland. In 1988 there were 291 and in 1989, 259 cases. By 1990 only 90 cases were reported. They also found a shift in the distribution of listeriosis in clinical types. Important changes occurred on the infections proportion during pregnancy and in newborns (38% of the total amount between 1983 and 1987), 42% (1988), 55% (1989) and 22% during the first 9 months of 1990.[14]

They also undertook studies on the patés sold on sale in 1989 and 1990, which confirmed the presence of L. monocytogenes. They noted that the paté from the “Y” factory was more likely to be contaminated by this bacterium and on higher levels than the other factories. From 107 paté samples from the Y factory, 51 (48%) were contaminated and in in 12 out of 50 (11% of all the samples from Y factory), there was a level of >1000/g despite 781 samples taken from other paté factories, in which 33 (4%) were contaminated and five of the 29 (0-6% from all the samples) had a level of >1000/g. Infected patients were interrogated to obtain a register of the consumed foods 3 weeks before contracting the disease and they found a significant association between recent paté intake and infection with the L. monocytogenes subtypes. Thirteen of the 15 patients whose disease was caused by L. monocytogenes had eaten paté during the 3 weeks before the disease.[14]

DISCUSSION

In Europe, the number of listeriosis outbreaks associated with dairies is now about half of the total outbreak amounts associated with any kind of foods. Mostly, these outbreaks have been linked to raw milk intake or products manufactured with it, as mellow cheeses. Although the first scientifically proven foodborne listeriosis outbreak occurred in 1981, raw milk has been formerly suspected of causing outbreaks.[13]

Even though most of the disease cases are due to the intake of non-pasteurized milk or subproducts made with it, outbreaks that occurred in spite of pasteurization show that this process does not eliminate the risk of later contamination. Therefore, pasteurized foods have the same risk consequence.[8]

Pini found high contamination levels of Listeria in soft paste cheeses.[10] Consequently, we consider so unacceptable the levels of the pathogen in cheese that it is clear, and it is clear, pregnant women should not include soft paste cheese in their diets until further notice. Also, ice-cream contamination after elaboration was observed, but quantitative data is very limited.[10]

The risk of contamination from other dairy products depends on many factors. Dairy-acidified products, such as cottage cheese, are free from this pathogen. There have been studies sustaining that L. monocytogenes tolerates adverse conditions and, therefore, can survive or grow in different kinds of foods. This pathogen can grow at low temperatures (−1.5-45°C) and at a wide pH range (4.3-9.1). It can also develop at saline concentrations up to 10-14% and tolerate low water activity, which allows it to survive in products with a high fat content, such as semi-hard cheeses.[11] It is resistant to alkaline mediums. It has the capacity to replicate in microaerophilic and anaerobic conditions and the concentrations of sodium nitrate allowed on food conserves do not inhibit the replication of the microorganism. It is clear that there is a temporal association with the implemented preventive measures. In fact,
the reduction of infections by L. monocytogenes and the decrease of the incidence implies a causal relationship.\(^{[11]}\)

The outbreak described by Dalton et al.\(^{[4]}\) was probably caused by post-pasteurization contamination due to poor sanitary practices at the milk company and exacerbated by keeping it at high temperatures on the way to the picnic, which allowed the fast bacterial growth, because it was found that the chocolate milk had very high levels of L. monocytogenes. The link between the invasive disease and the implicated milk was confirmed at Wisconsin by pulsed-field gel electrophoresis. It is considered that this pathogen is more resistant to the pasteurization process when inside a bovine phagocyte than when freely suspended in milk. High temperature during short-time pasteurization, at a 71.7°C temperature for 15 s or at 62.5°C for 30 min can transfer and allow L. monocytogenes to survive and replicate.\(^{[15]}\)

Incorrect milk pasteurization and its subsequent contamination are the most possible explanations for the presence of pathogens on pasteurized milk. Some of the milk bacteria produced by cows with bovine mastitis may survive the pasteurization and replicate themselves at refrigeration temperatures. Even when contamination with pasteurized milk bacterias is demonstrated, it is hard to determine the way and the source of such contamination. Raw milk is an essentially dangerous product and, as such, it should never be added to the pasteurized product.\(^{[3]}\)

The pioneering work of Fleming et al.\(^{[3]}\) established that the milk implicated in this case was properly pasteurized, the question of when the milk got contaminated takes great importance. Although post-pasteurization contamination cannot be excluded, it does not seem to be difficult, because multiple inspections made over the production factory did not show any potential source of contamination and, besides, it is difficult to postulate a mechanism by which the post-pasteurization contamination affects only whole milk and not skimmed milk, because both were processed with the same equipment.\(^{[3]}\)

On the other hand, intrinsic contamination of milk and survival of some of the microorganisms besides a proper pasteurization are quite consistent with the investigation results and biologically plausible. When cattle is infected, the organism is excreted in the milk due to which L. monocytogenes is quite resistant to heat and milk’s post-pasteurization storage at a refrigeration temperature might allow the selective growth of the remaining organisms. In fact, a relatively small infective dose might be the cause of immunocompromised adult patients getting sick. It is known that the skill of L. monocytogenes of existing as an intracellular parasite might increase the chance of survival of some of the microorganisms after milk pasteurization.\(^{[4]}\)

Listeriosis with milk consumption association supports the hypothesis that L. monocytogenes is a pathogen transmitted to humans from infected animals or their products and that the consumption of the microorganism is an infection mechanism.\(^{[5]}\) The results suggest that milk should be considered as a possible infection vehicle on sporadic listeriosis cases and that even when pasteurization is a highly effective method to eliminate pathogens from milk, it might not always be 100% effective.\(^{[3]}\)

On the other hand, diverse studies do not recommend a change in the consumption habits of these groups, but they do recommend not to use fresh manure on farms to fertilize crops that will be kept in cold during a long period of time and that are usually consumed raw.\(^{[13]}\) The findings of M.Lauchlin\(^{[4]}\) gave evidence about a relationship between some cases and paté consumption. There were no direct microbiological evidences obtained to ensure a relationship between cases and consumption of these foodstuffs because there were no samples of the eaten paté available.

In the outbreak described by Boggs,\(^{[7]}\) it was seen that even though laws forbade the sale and consumption of raw milk and raw dairy products, as in North Carolina, such practices persist in some communities as a result of the taste preferences for these kind of cheeses. Unfortunately, the renown of the fresh homemade Mexican-style cheese elaborated with non-pasteurized milk has given rise to several outbreaks inside Hispanic communities since the 80’s, with septic miscarriages as a consequence attributed to L. monocytogenes. Also, the fact that the other 28 states allow the sale of raw milk to consumers, making alimentary education to the population difficult, and as the cheese on these communities is produced at private homes, regulations at a sanitary level are hard to observe. Furthermore, it has also added to the difficulty to communicate successfully the public health messages to the Hispanic community about the risk that implies the consumption of these kind of products due to the language and other social and cultural barriers.\(^{[7]}\)

Tapero et al.\(^{[16]}\) analyzed if the reduction of the incidence of listeriosis on the United States from 1989 to 1993 could have occurred due to effective prevention measures that were applied during this period at an industrial regulation and educational level. The consumption of poorly cooked aviary products and hot dog were detected as a risk factor. Mellow cheeses were involved after a microbiological research made on samples of such food found in the refrigerator of the patients. On the other hand, it was seen that listeriosis rates decreased in all the observed areas. One thousand nine hundred sixty-five cases were estimated and 481 deaths occurred in 1989 compared with 1092 estimated cases and 248 deaths in 1993, a reduction of 44% and 48% on the disease and deaths, respectively. It was a clear relationship between the control of the food industry to prevent the contamination with Listeria and the prevention of human disease.\(^{[14]}\)

Although the source for most of the infections by Listeria remains unknown, it is a very convincing proof of food transmission in humans, which might be responsible for epidemics, outbreaks and sporadic cases.\(^{[11]}\) It is important to maintain the perspective on the listeriosis problem when explaining to patients about the low incidence of prenatal listeriosis and that only a few pregnant patients acquired listeriosis.\(^{[12]}\) This last fact does not come as a comfort for those patients who carry on with their pregnancy.
and give birth to a handicapped child or a dead fetus. In the initial prenatal visit, pregnant women should be advised not to drink raw milk, eat soft and cured cheeses and to wash correctly fruits and vegetables. On the other hand, pre-cooked foods and ready-to-eat birds should not be consumed cold. If these foods are included in the diet, they should only be consumed if they have previously been heated at over 75ºC.[15]

To prevent the disease, dairies should supervise their final products and control the general sanity level of the plant by correct cleaning, sanitization and equipment maintenance according to the Hazard Analysis and Critical Control Points. Expiration dates should be based on those proven results.[14] The population should be informed, especially women, that cooked foods should be kept in the refrigerator on a different compartment, away from cheeses and raw foods.[8] It must be mentioned that this food must be kept for the shortest possible time and to respect the expiration dates of the labels. When a microwave is used, patients should pay attention to the manufacturer instructions to ensure a uniform temperature on the foods. Also, reheated leftovers must be discarded. It is important for the patient to know these facts, although it remains to be determined the extent to which listeriosis cases are sporadic or are part of an outbreak and the frequency with which they are related to the food.[13]

CONCLUSION

Because of the lack of information about the contamination rate of the foods and the risk of invasive disease of vulnerable pregnant women exposed to the pathogen, it is hard to recommend the elimination from the diet of some kind of foods.[6] However, the patient must be told about the capacity of the pathogen to replicate frequency with which they are related to the food.[13]

A study made in France by the National Reference Center of Listeriosis as well as Tappero’s researches found an association between the use of preventive measures on the food industry and the decrease of listeriosis incidence.[14] They observed that the incidence started to fall between 1987 and 1992, when the preventive measures started to apply at a production level.[11] Data obtained from the monitoring of foods suggest that the application of these measurements reduce successfully the distribution of L. monocytogenes on ready-to-eat foods.[18]

Clearly, there is a lot remaining to elucidate about the epidemiological aspects of listeriosis because it is an evolving sanitary problem. An effort made together between the nutritionist, microbiologist, physician and epidemiologist is essential. A removable inference from the main epidemic published outbreaks is that if listeriosis epidemics are caused by food transmission, they might also produce, in the same way, even greater sporadic cases.[11]

REFERENCES


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