Bad Bug Book
Foodborne Pathogenic Microorganisms and Natural Toxins

Listeria monocytogenes

1. Organism

Listeria monocytogenes is a Gram-positive, rod-shaped, facultative bacterium, motile by means of flagella, that is among the leading causes of death from foodborne illness. It has 13 serotypes, including 1/2a, 1/2b, 1/2c, 3a, 3b, 3c, 4a, 4ab, 4b, 4c, 4d, 4e, and 7. Among them, serotypes 1/2a, 1/2b, and 4b have been associated with the vast majority of foodborne infections.

L. monocytogenes is hardy; it is salt-tolerant and not only can survive in temperatures below 1°C, but also grow in these conditions, unlike many other pathogens. It is also notable for its persistence in food-manufacturing environments. The bacterium is ubiquitous in the environment and can be found in moist environments, soil, and decaying vegetation.

Of the five other species in the genus *Listeria* – *L. grayi, L. innocua. L. ivanovii, L. seeligeri* and *L. welshimeri* – only *L. ivanovii* is considered pathogenic, and mainly in ruminants, rather than in humans.

For Consumers: A Snapshot

Although the number of people infected by foodborne *Listeria* is comparatively small, this bacterium is one of the leading causes of death from foodborne illness. It can cause two forms of disease. One can range from mild to intense symptoms of nausea, vomiting, aches, fever, and, sometimes, diarrhea, and usually goes away by itself. The other, more deadly form occurs when the infection spreads through the bloodstream to the nervous system (including the brain), resulting in meningitis and other potentially fatal problems. Pregnant women are more susceptible to *Listeria* infection than are most other people, and although they generally recover, their babies usually don't survive. People with weak immune systems also are more vulnerable (for example, those with AIDS or chronic diseases, or who are on certain immune-suppressing arthritis drugs or cancer chemotherapy). Because our immune systems weaken as we age, the elderly also are especially vulnerable to this pathogen. *Listeria* cases have been traced back to several foods; for example, raw or under-pasteurized milk; smoked fish and other seafood; meats, including deli meats; cheeses (especially soft cheeses); and raw vegetables. *Listeria* is hardy; it tolerates salty environments and cold temperatures, unlike many other foodborne bacteria. You can help protect yourself from infection with *Listeria* by ***not*** drinking ***un***pasteurized milk (also called "raw" milk) or certain cheeses or other foods made with raw milk; and by cooking food according to instructions; washing fruits and vegetables; keeping raw foods from touching other foods, dinnerware, kitchen counters, etc.; and washing your hands and other things that have come into contact with raw foods.

2. Disease

- **Mortality**: Although not a leading cause of foodborne illness, *L. monocytogenes* is among the leading causes of death from foodborne illness. A recent report by the Centers for Disease Control and Prevention (CDC) estimated that domestically acquired foodborne *L. monocytogenes* causes 255 deaths in the U.S. annually. The severe form of the infection has a case-fatality rate of 15% to 30%, overall. When listerial meningitis occurs, the case-fatality rate may be as high as 70%; from septicemia, 50%, overall; and in perinatal/neonatal infections, more than 80%.

- **Infective dose**: The infective dose of *L. monocytogenes* is undetermined, but is believed to vary with the strain and susceptibility of the host, and the food matrix involved also may affect the dose-response relationship. In cases associated with raw or inadequately pasteurized milk, for example, it is likely that fewer than 1,000 cells may cause disease in susceptible individuals. As noted, however, the infective dose may vary widely and depends on a variety of factors.

- **Onset**: Gastroenteritis caused by *L. monocytogenes* has a relatively short incubation period, from a few hours to 2 or 3 days. The severe, invasive form of the illness can have a very long incubation period, estimated to vary from 3 days to 3 months.

- **Illness / complications:** *L. monocytogenes* infection causes two forms of disease in humans:

  1) non-invasive gastrointestinal illness, which generally resolves in otherwise healthy people.

  2) the much more serious, invasive form of the illness, which may cause septicemia and meningitis.

  Manifestations of *L. monocytogenes* infection tend to be host-dependent. In people with intact immune systems, it may cause acute febrile gastroenteritis, the less severe form of the disease. In vulnerable populations, however, the more severe form of the disease may result in sepsis and spread to the nervous system, potentially causing meningitis. In elderly and immunocompromised people who develop the severe form, it usually manifests in this manner.

  Pregnant women, who are disproportionately infected with *L. monocytogenes*, may experience mild, flu-like symptoms; however, their offspring do not fare as well – they may abort or be stillborn, and those born alive may have bacteremia and meningitis. One-third of confirmed cases of maternal-fetal *L. monocytogenes* infections lead to abortion or stillbirth.

- **Symptoms**: Otherwise healthy people might have mild symptoms or no symptoms if infected with *L. monocytogenes*, while others may develop fever, muscle aches, nausea and vomiting, and, sometimes, diarrhea. When the more severe form of the infection develops and spreads to the nervous system, symptoms may include headache, stiff neck, confusion, loss of balance, and convulsions.

- **Duration**: The duration of symptoms generally depends on the health status of the infected person. The symptoms can last from days to several weeks.

- **Route of entry**: Oral.

- **Pathway**: The pathogenesis of *L. monocytogenes* is unique, because the organism is able to spread directly from cell to cell in the host, rather than having to "travel" interstitially to reach other cells. Once the bacterium enters the host's monocytes, macrophages, or polymorphonuclear leukocytes, it can reproduce, and it is bloodborne. Groups of proteins on the *L. monocytogenes* cell surface enable it to survive in phagocytic cells and enhance its cell-to-cell spread.

3. Frequency

Based on a survey collected through 1997 by the Centers for Disease Control and Prevention (CDC), listeriosis was responsible for approximately 2,500 illnesses and 500 deaths in the United States annually. By 2008, the number of *L. monocytogenes* infections had declined 36 percent, compared to the period from 1996 to 1998. There was a moderate increase in the incidence of *L. monocytogenes* from 2008 to 2009; however, it was still lower than the incidence measured 10 years before that. More recently, the 2011 CDC report cited above estimated that *L. monocytogenes* causes 1,591 cases annually.

4. Sources

Many foods have been associated with *L. monocytogenes*. Examples include raw milk, inadequately pasteurized milk, chocolate milk, cheeses (particularly soft cheeses), ice cream, raw vegetables, raw poultry and meats (all types), fermented raw-meat sausages, hot dogs and deli meats, and raw and smoked fish and other seafood. *L. monocytogenes* can grow in refrigerated temperatures, which makes this organism a particular problem for the food industry.

Potential contamination sources include food workers, incoming air, raw materials, and food-processing environments. Among those, post-processing contamination at food-contact surfaces poses the greatest threat to product contamination.

5. Target Populations

The main target populations for listeriosis are:

- pregnant women/fetuses/neonates - perinatal and neonatal infections;
- persons immunocompromised by, for example, corticosteroids, anticancer drugs, graft suppression therapy, AIDS;
- cancer patients, particularly leukemic;
- (less frequently reported) diabetic, cirrhotic, asthmatic, and ulcerative colitis patients;
- the elderly;
- healthy people – some reports suggest that healthy people are at risk, and that antacids or cimetidine may predispose them to the infection. Some studies suggested that healthy, uncompromised people could develop the disease, particularly if the food eaten was heavily contaminated with *L. monocytogenes*.

6. Diagnosis

Identification of culture isolated from tissue, blood, cerebrospinal fluid, or another normally sterile site (e.g., placenta or fetus) is needed for diagnosis of *L. monocytogenes* infection. Stool cultures are not informative, since some healthy humans may be intestinal carriers of *L. monocytogenes*.

7. Food Analysis

Methods of analyzing foods for purposes of identifying *L. monocytogene*s are complex and time-consuming. The present FDA method, revised in January 2003, uses a single enrichment broth, buffered *Listeria* enrichment broth, and requires 24 to 48 hours of enrichment, followed by a variety of agars and, finally, biochemical confirmation. Total time to identification is from 5 to 7 days. Many other enrichment broths, such as UVM broth and Fraser broth, are also included in various protocols. Agars that have been extensively evaluated include Oxford agar, PALCAM, LPM plus esculin and ferric iron and MOX.

New molecular biology techniques have been used to develop various rapid-screening kits for *L. monocytogenes*. These kits generally rely on ELISA, PCR, and probe-based identification.

8. Examples of Outbreaks

L. monocytogenes has caused significant outbreaks worldwide over the past decades. Some examples are listed below.

Los Angeles, 1985. A large-scale listeriosis outbreak occurred in Los Angeles County, California, due to the consumption of contaminated Mexican-style soft cheese. Human listeriosis cases reported numbered 142. Among them, 93 cases occurred in pregnant women or their offspring, and the remaining cases occurred in non-pregnant adults. The outbreak led to 48 deaths, including 20 fetuses, 10 neonates, and 18 non-pregnant adults. An investigation of the cheese plant suggested that the cheese was commonly contaminated by unpasteurized milk. The outbreak strain was serotype 4b.

U.S., 1989, 2000. A serotype 1/2a strain was isolated from a single case of human listeriosis in 1989, which was caused by the consumption of processed meat. Eleven years later, the same strain isolated from sliced turkey produced by the same processing plant was implicated in a listeriosis outbreak. This provides a powerful illustration of *L. monocytogenes's* tenacity and prolonged survival in food-processing environments.

U.S., 1998 to 1999. A large scale multistate outbreak of listeriosis caused at least 50 cases in 11 states. Six adults died, and two pregnant women had spontaneous abortions. Contaminated hot dogs were linked to this outbreak. All *L. monocytogenes* isolates from these cases were serotype 4b.

U.S., 2002. A multistate outbreak of listeriosis in the Northeastern U.S. resulted in 46 cases, including 7 deaths and 3 stillbirths or miscarriages in eight states. The outbreak was linked to eating sliceable turkey deli meat. *L. monocytogenes* was isolated from 1 food product and 25 environmental samples from a poultry-processing plant. The isolate from the food product had a PFGE pattern different from the outbreak strain; however, two environmental isolates from floor drains had an identical PFGE pattern to that of outbreak patient isolates, suggesting that the plant might have been the source of the outbreak. The outbreak strain was serotype 4b.

Canada, 2008. A widespread outbreak of listeriosis occurred in Canada and was linked to deli meat produced by a Maple Leaf Foods plant in Toronto, Ontario. The outbreak caused 57 confirmed cases in seven provinces, and 22 people died. The outbreak strain was serotype 1/2a.

9. Resources

- Loci index for genome *Listeria*.
- GenBank Taxonomy database.
- CDC facts about listeriosis.
- The U.S. Department of Agriculture provides information about *Listeria monocytogenes*.