Chapter

Prologue: *Escherichia coli*, *Listeria*, and *Salmonella*

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1. Introduction

The present book deals with the following microorganisms: *E. coli*, *Salmonella*, and *Listeria*. The first two are Gram-negative bacteria belonging to the group of Enterobacteriaceae with the characteristic of becoming resistant to the most common antibiotics; whereas, the last one is a Gram-positive bacterium belonging to *Corynebacterium*, *Erysipelothrix*, and other Gram-positive microorganisms showing an involvement in pathologies as newborn meningitis and gynecological infection which may interfere with the pregnancy outcome. The peculiarity of all these bacteria is that they can be transmitted by contaminated food.

2. *E. coli*

Scientific classification
Domain: Prokaryota
Kingdom: Bacteria
Phylum: Proteobacteria
Class: Gamma Proteobacteria
Order: Enterobacteriales
Family: Enterobacteriaceae
Species: *E. coli*

The bacteria, in fact, can be found in the gastrointestinal tract (GI) of humans and animals, but they are mainly considered as ubiquitous microorganisms.

This bacterium includes a single species (*E. coli*) and is divided into 171 serotypes, aerobic-anaerobic Gram-negative rods with flagella fimbriae, and able to ferment glucose and lactose.

The most important serotype is *Escherichia coli* O157:H7 or enterohemorrhagic *Escherichia coli* (EHEC), which often leads to enterohemorrhagic diarrhea and is also able to induce hemolytic uremic syndrome (HUS) which is characterized by acute renal failure, hemolytic anemia, and thrombocytopenia that are more common in children and in elderly people [1].

Serotype O157-H7 causes numerous outbreaks and sporadic cases of bloody diarrhea. Foodborne pathogenic E. coli contamination, such as that with *E. coli* O157 and O104, is very common even in developed countries. Bacterial contamination may occur from environmental, animal, or human sources and cause foodborne illness [2].

The three main diseases, depending on each particular serotype involved, are urinary tract infections, intestinal diseases, and neonatal meningitis [3].

Many different mechanisms of action are reported regarding the virulence of *E. coli*. Although most strains are saprophytic colonizing the large bowel, some types of them are involved in different pathologies such as traveler's and childhood

diarrhea (ETEC and EPEC also in Mexico and North Africa EAEC), hemorrhagic colitis (EHEH), and a Shiga-like disease (EIEC). As far as this last point is concerned, it is reported that the differentiation between *Shigella* and *E. coli* is quite more complicated when we consider enteroinvasive *E. coli* (EIEC). In fact, EIEC are strains that are similar to *E. coli* but are able to cause dysentery using the same method of invasion as *Shigella*. In fact, in this specific situation, EIEC is more related to *Shigella* than to non-invasive *E. coli* [4]. This strain is among the most common cause of foodborne diseases other than of neurological and renal complications, especially in children.

Escherichia coli K1 strains are major causative agents of invasive disease of newborn infants. Colonization of the small intestine following oral administration of K1 bacteria leads rapidly to blood stream infections (BSI). Indeed, these microorganisms are the cause of life-threatening infections that are acquired from the mother at birth thus colonizing the small intestine, from where they invade the blood and central nervous system.

E. coli is increasingly present as a MDR (multi-drug resistant) bacterium, in fact its genomic outfit has acquired various antibiotic resistances through the production of ESBL [5] and carbapenemases as well as metallo-beta lactamases (NDM = New Delhi metallo-beta lactamases) making the infections of this bacterium extremely worrying [6] (**Figures 1** and **2**).

3. *Listeria monocytogenes*

Class: Bacilli
Kingdom: Bacteria
Family: Listeriaceae
Classification: *Listeria*

Listeria monocytogenes is a Gram-positive, mobile, rod-shaped bacterium that is ubiquitous in the environment. It can be isolated in soil and wood and decays in the natural environment; however, the principal acquisition of *Listeria* is through the ingestion of contaminated food products. *Listeria* is a foodborne pathogen that contaminates food-processing environments and persists within biofilms in the surroundings. The peculiar characteristic of this microorganism is its ability to grow even in extreme situations, such as under high salt conditions and refrigeration temperatures, maintaining its vitality in various food products [7]. Even though the incidence of listeriosis is lower than other enteric illnesses, infections caused by *L. monocytogenes* are more serious and may lead to hospitalizations and fatalities. These infections mainly affect women and children who acquire the disease

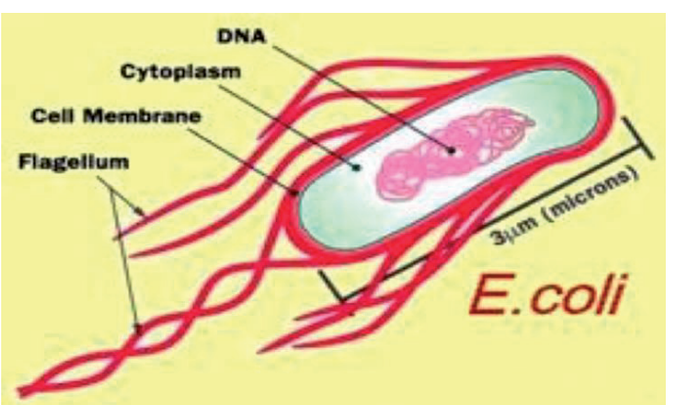

Figure 1.
Morphology of E. coli. *http://www.lacolonscopia.it/colonscopia/escherichia-coli-come-prevenirlo-e-curarlo/*

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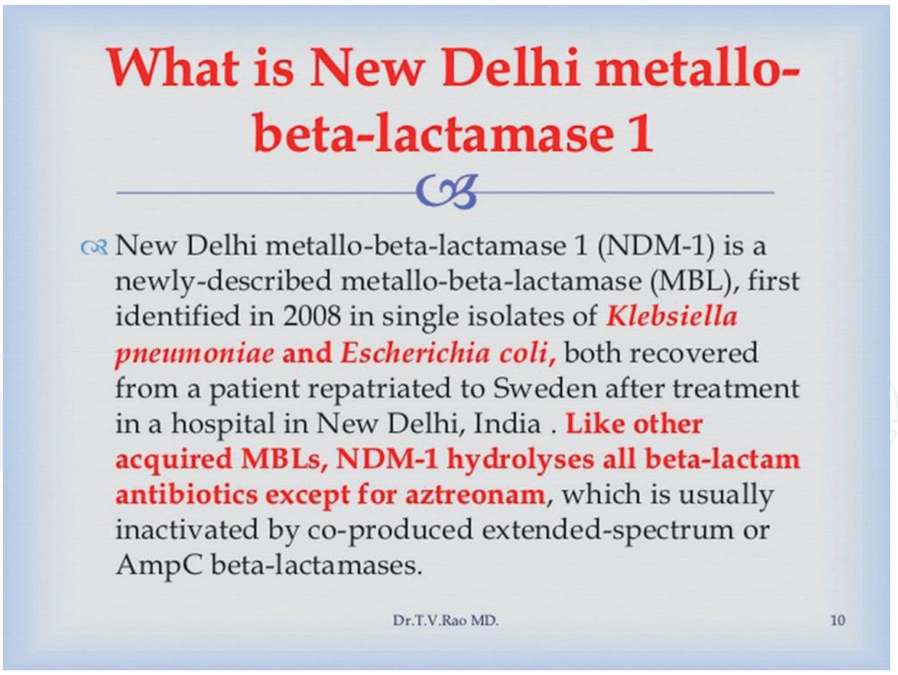

Figure 2.
Slide from "New Delhi metallo-beta-lactamase (NDM-1). Facts, controversies, solutions. An update" T.V. Rao (Powerpoint 2016). https://www.slideshare.net/doctorrao/new-delhi-metallobetalactamse

through vertical transmission from mother to infant during pregnancy or childbirth. Nosocomial infections between children are rare but anyhow they were reported. The most important disease for the newborns is the neonatal meningitis, which shows a high degree of mortality (higher in the developing countries which can reach 40–58% of cases). Listeriosis requires rapid treatment with antibiotics and most drugs suitable for Gram-positive bacteria are effective against *L. monocytogenes*. Generally, the *Listeria* clinical strains are susceptible to the common antibiotics because only a minority results as being resistant to antimicrobial agents. In the same way, several

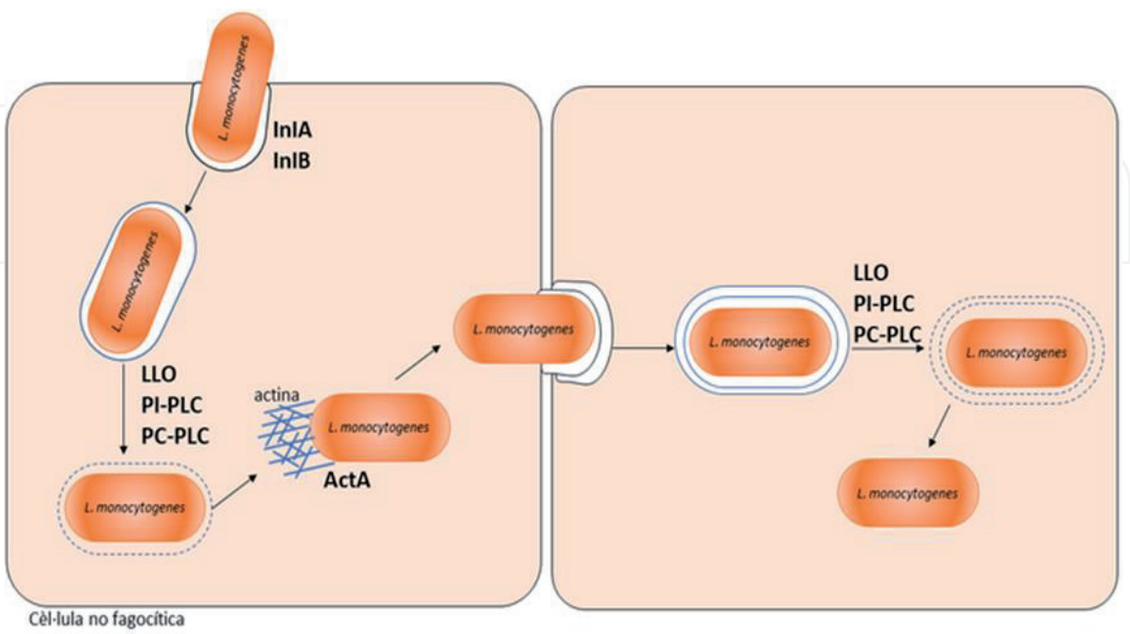

Figure 3.
Phagocytosis of Listeria. Legenda: (internalins InlA and InlB), phagosome lysis (listeriolysin O (LLO)), phosphatidylinositol-specific phospholipase C (PI-PLC) and phosphatidylcholine ((PC)-PLC), cell-to-cell spread (actin assembly-inducing protein (ActA)), intracellular growth (hexose-6-phosphate transporter (Hpt)) [10].

strains detected from food exhibited resistance to antimicrobials not suitable against listeriosis [8]. Pregnant women can carry *Listeria* asymptomatically in their gastrointestinal tract or vagina and the risk of transmitting this infection to their babies is high. The consequence of listeriosis to human health is a very important issue due to its virulence mainly in children with an underlying immunodeficiency. Symptoms include fever, headache, abdominal pain, diarrhea, vomiting, and convulsions. The complications can be appendicitis and Meckel's diverticulitis [9].

Listeria which is saprophyte in the environments such as water, soil, and food, once internalizes into the mammalian host, shows its virulence through the expression of many gene products reported in **Figure 3** [10].

4. *Salmonella*

Domain: Prokaryota
Kingdom: Bacteria
Phylum: Proteobacteria
Class: Gammaproteobacteria
Order: Enterobacteriales
Family: Enterobacteriaceae
Genre: *Salmonella*

Salmonella is the most commonly isolated bacterial agent of foodborne and epidemic infections. It was reported for the first time in 1886, in a case of swine fever by the American doctor Daniel Elmer Salmon.

The genus *Salmonella* is characterized by Gram-negative facultative anaerobic bacilli without spores. They are mobile through peritrichous flagella with the exception of *S. gallinarum* and *S. pullorum*. The serotypes are diversified according to the somatic antigen "O," the flagellar antigen "H" and the surface antigen "Vi." The Vi antigen is exclusively expressed by *S. typhi* and is able to circumvent the innate immune response by repressing flagellin and LPS expression [11]. The "O" antigens are distinguished in the serogroups A, B, C1, C2, D, and E.

Salmonella is present in the environment and can be either commensal or pathogen for men and various animals; some serotypes are exclusively pathogen for humans (i.e., *S. typhi* and *S. paratyphi* A and C), others infect both humans and animals such as *S. typhimurium* [12].

In humans, there are two kind of infectious diseases:

1. typhoid and paratyphoid fever [13]

2. minor salmonellosis [14]

Salmonella infection is transmitted through fecal route by the ingestion of contaminated food and drink. *Salmonella typhi* is responsible for typhoid fever, and its transmission can occur, especially in developing countries, by water and food infected or with direct contact among people, especially in poor hygienic conditions. The minimum infectious dose can be less than 15–20 cells. Individual sensitivity depends on the patients' age and on the nature of *Salmonella* strains.

In most cases, *Salmonella* infection occurs in mild form and resolves on its own within a few days. In these situations, the advice is not to consider the diarrheal phenomenon, since it is the natural defense mechanism used by the organism to expel germs. Normally, for S*almonella*, it should be enough to adopt a supportive therapy: administration of oral rehydration solutions (which are used to compensate for water and salts lost with vomiting and diarrhea), lactic ferments, and probiotics.

Although salmonellosis is a bacterial infection, the use of antibiotics is not recommended as it could lengthen the persistence time of *Salmonella* in feces or induce antimicrobials resistance [15]. Hospitalization and the use of antibiotics are indicated only in severe cases (with extra-intestinal symptoms), in infants under 3 months and in subjects with chronic-degenerative diseases.

In recent times, *Salmonella* has changed its characteristics worldwide, becoming the etiologic agent of many peculiar pathological processes such as cancer development, inflammatory process, and immune-pathogenesis [16, 17] (**Figure 4**).

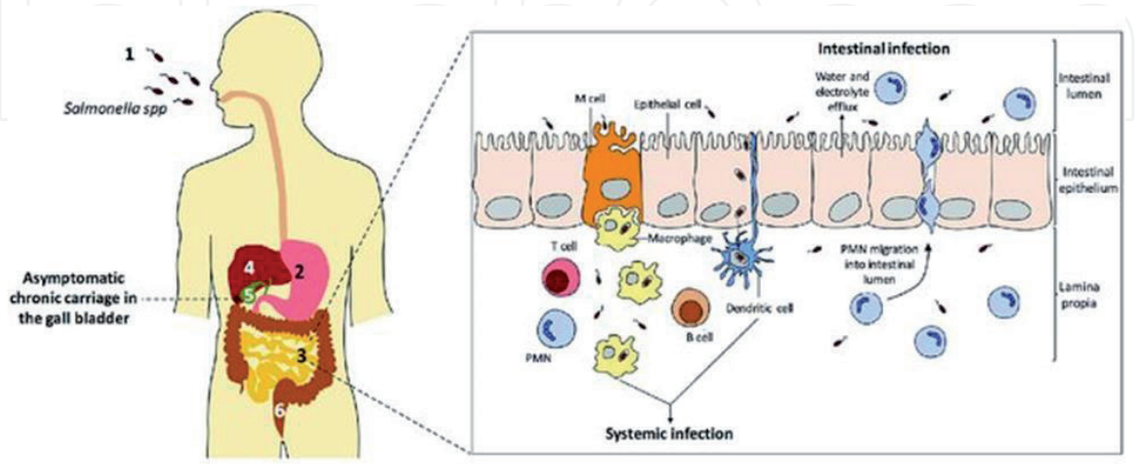

Figure 4.
Salmonella *infection pathogenesis. The ingestion of contaminated food or water begins the infective processes (gastroenteritis or systemic infection) depending on the species of* Salmonella *involved (minor and major Salmonellae). The microorganisms reach the intestinal epithelial cells and migrate to the lamina propria invading the liver from where* Salmonella *reaches the gall bladder and can cause chronic carriage which gives rise to healthy carriers [18].*

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