The salmonella

Salmonellae are often pathogenic for humans or animals when acquired by the oral route. They are transmitted from animals and animal products to humans, where they cause

1. Enteritis
2. Systemic infection
3. Enteric fever.

Morphology and Identification

1. Most isolates are motile with peritrichous flagella.
2. Never ferment lactose or sucrose.
3. Form acid and sometimes gas from glucose and mannose.
4. Usually produce H2S.
5. Survive freezing in water for long periods.
6. Resistant to certain chemicals.
7. Gram-negative, facultative anaerobic rods
8. Oxidase negative
9. Lipopolysaccharide consists of outer somatic O polysaccharide, core polysaccharide (common antigen), and lipid A (endotoxin)
10. More than 2500-O serotypes (commonly referred to as individual Salmonella species)

**Classification**

- Currently, the genus *Salmonella* is divided into Two Species each with multiple subspecies and serotypes.
- The two species are *Salmonella enterica* and *Salmonella bongori*
- *S enterica* contains five subspecies, which are:
  - subspecies *enterica* (subspecies I)
  - subspecies *salamae* (subspecies II)
  - subspecies *arizonae* (subspecies IIIa)
  - subspecies *diarizonae* (subspecies IIIb)
  - subspecies *houtenae* (subspecies IV)
  - subspecies *indica* (subspecies VI)

  - Most human illness is caused by the subspecies I strains, written as: *S enterica subspecies enterica*.
  - Accepted nomenclature for classification will be as follows:
    - *S enterica subspecies enterica* serotype *Typhimurium*, which can be shortened to:

    **S. typhimurium**

  - Four serotypes of Salmonellae that cause Enteric fever can be identified in the clinical laboratory by biochemical and serologic tests. These serotypes should be routinely identified because of their clinical significance.

They are as follows:

1. *Salmonella paratyphi A* (serogroup A)
2. *Salmonella paratyphi B* (serogroup B)
3. *Salmonella choleraesuis* (serogroup C1)

**Variation**

Organisms may lose H antigens and become nonmotile. Loss of O antigen is associated with a change from smooth to rough colony form. Vi antigen may be lost partially or completely. Antigens may be acquired (or lost) in the process of transduction.
In humans, *Salmonella* are the cause of two diseases called salmonellosis:
1. **Enteric fever (typhoid)**, resulting from bacterial invasion of the bloodstream,
2. **Acute gastroenteritis**, resulting from a foodborne infection/intoxication.

**Pathogenesis and Clinical Findings**
- Animal reservoir for human infection is the **poultry, pigs, rodents, cattle, pets (from turtles to parrots), and many others.**
- The organisms almost always enter via the **oral route**, usually with contaminated food or drink. The mean infective dose to produce clinical or subclinical infection in humans is $10^5–10^8$ salmonellae (but perhaps as few as $10^3$ S. Typhi organisms).

**The “Enteric Fevers” (Typhoid Fever)**
- This disease is produced by only a few of the salmonellae, of which *S Typhi* is the most important.
- The ingested salmonellae reach the SI, from which they enter the lymphatics and then the BS. They are carried by the blood to many organs, including the intestine.
- After an incubation period of 10–14 days, **fever, malaise, headache, constipation, bradycardia, and myalgia** occur. The fever reach a high plateau, and the **spleen and liver become enlarged**. **Rose spots** usually on the skin of the abdomen or chest, are seen briefly in rare cases.
- Hyperplasia and necrosis of lymphoid tissue (eg, Peyer’s patches); focal necrosis of the liver; and inflammation of the gallbladder, periosteum, lungs, and other organs.

**Mechanisms of pathogenicity**
Bacterial products involved in virulence:
- *Salmonellae* owe their pathogenicity largely to their ability to **invade tissue** and to **survive within macrophages**.
The VI antigen is a capsule that affords salmonellae some protection from phagocytosis.

Once phagocyted, S.typhi inhibits generation of oxidative free radicals and intraphagosomal killing.

Additionally, salmonellae have endotoxic lipopolysaccharide, which is responsible for septic shock in patients with bacteriemia.

Salmonellae that cause enteritis produce at least two enterotoxins that are responsible for many of the clinical signs of enteritis.

The first of these is a small (25-30kD) protein that binds to GM1 gangliosides and cause hypersecretion of fluids and electrolytes by elevating levels of cAMP.

The second enterotoxin is larger (about 100 kD) and is unrelated in structure and mechanism of activity to the first enterotoxin.

**Bacteremia with Focal Lesions**
- This is associated commonly with *S. choleraesuis*
- After oral infection, there is early invasion of the bloodstream (with possible focal lesions in lungs, bones, meninges, and so on), but intestinal manifestations are often absent.

**Diagnostic Laboratory Tests**
**Specimens:** Blood, Urine, Faeces, Aspirated duodenal fluid, etc.

**Bacteriologic Methods for Isolation of Salmonellae**
1. Differential medium cultures
   - **Enrichment broth:** Tetrathionat, selenit broth
   - **Selective media:** MacConkey, S-S agar, Hektoen Enteric Agar, Bismuth sulfide agar
2. Final identification: Biochemical tests

API identification kit

Serologic Methods: Agglutination test (Widal test)

**Immunity**
- Active immunity
- Passive immunity - the temporary immunity that an infant acquires from its mother
Prevention and control

- Sanitary measures.
- Carriers must not be allowed to work as food handlers.
- Strict hygienic precautions for food handling.
- Vaccines against S. Typhi:
  1. Purified Vi antigen
  2. Oral, live attenuated vaccine.

The Brucellae

- Gram negative but often stain irregularly, nonmotile.
- Small (0.5 × 0.6 to 1.5 μm), nonencapsulated
- Strictly aerobic
- Does not ferment carbohydrates
- Varies from cocci to rods, with short coccobacillary forms predominating.
- Grows slowly
- Endotoxin is less toxic
- Intracellular parasite
- The organisms are phagocytosed by macrophages and monocytes
Phagocytosed bacteria are carried to the spleen, liver, bone marrow, lymph nodes
- The bacteria secrete proteins that induce granuloma formation
- Obligate parasites of animals and humans, inactive metabolically.
- Species of Brucella include the following:
  1. *Brucella melitensis* typically infects goats
  2. *Brucella suis*, swine
  3. *Brucella abortus*, cattle

The disease in humans, brucellosis (undulant fever, Malta fever), is characterized by an **acute bacteremic phase** followed by a **chronic stage** that may extend over many years and may involve many tissues.

**Growth Characteristics**
- Fresh specimens inoculated on trypticase-soy agar or blood culture media.
- Brucellae use carbohydrates but produce neither acid nor gas.
- **Catalase** and **oxidase** are produced by the four species.
- **Hydrogen sulfide** is produced by many strains, and nitrates are reduced to nitrites.
- **Killed in milk by pasteurization.**

**Pathogenesis and Pathology**
- The common routes of infection in humans are
  1. **The intestinal tract** (ingestion of infected milk)
  2. **Mucous membranes** (droplets)
  3. **Skin** (contact with infected tissues of animals).
- Cheese made from unpasteurized goats’ milk is a particularly common vehicle.
- The organisms progress from the portal of entry via **lymphatic channels** and **regional lymph nodes** to the **bloodstream**, which distributes them to the organs.
- Incubation period 1-6 weeks
- A chronic state may occur
Placentas and fetal membranes of cattle, swine, sheep, and goats contain erythritol, a growth factor for brucellae. The proliferation of organisms in pregnant animals leads to placentitis and abortion in these species.

**Clinical Findings**
- malaise, fever, weakness, and sweats.
- The fever usually rises in the afternoon; its fall during the night is accompanied by drenching sweat.
- Granulomatous nodules may develop into abscesses form in lymphatic tissue, liver, spleen, bone marrow.
- Lymph nodes enlarge, SM, Hepatitis, Osteomyelitis, may be gastrointestinal and nervous symptoms.

**Diagnostic Laboratory Tests**

A. **Specimens**
Blood should be taken for culture, biopsy material for culture (lymph nodes, bone, and so on), and serum for serologic tests (Rose Bengal test).

B. **Culture**
- *Brucella* agar was specifically designed to culture *Brucella* species bacteria.
  - Enriched blood agars
  - Microscopic and colonial morphology
  - Positive oxidase and urease reactions

**Immunity**
- IgM, IgG, IgA
- Titer 1/80 indicate active infection
- If agglutination negative “blocking antibodies”

**Epidemiology, Prevention, and Control**
The common sources of infection for humans are *unpasteurized milk, milk products, and cheese as well as occupational contact* (eg, farmers, veterinarians, and slaughterhouse workers) **with infected animals.**