

## Chapter 28 Foodborne Gastroenteritis Caused by *Vibrio*, *Yersinia*, and *Campylobacter* Species

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### VIBRIOSIS

- ◆ *Vibrio parahaemolyticus* (副溶血性弧菌/腸炎弧菌) gastroenteritis is contracted almost solely from **seafood**.
- ◆ Natural habitat → the sea
- ◆ Three other *Vibrio* species (Table 28-1)
  - *V. vulnificus* (創傷性弧菌/海洋弧菌)
  - *V. alginolyticus* (溶藻弧菌)
  - *V. cholerae* (霍亂弧菌)



## *Vibrio parahaemolyticus*

### Growth Conditions

- ◆ **1 – 8 % NaCl**
- ◆ Dies off in distilled water
- ◆ Not grow at 4°C, but **grow between 5 – 9°C**
- ◆ The upper growth temperature is 44 °C, with an optimum between **30 °C and 35 °C**.
- ◆ pH range **4.8 – 11.0**, with 7.6 – 8.6 being optimum.
- ◆ Under optimal conditions → **a generation time of 9 – 13 minutes** (compared to about 20 minutes for *E. coli*).
- ◆ **Heat sensitive**, with D<sub>47°C</sub> values ranging from 0.8 – 65.1 minutes.



## *Vibrio parahaemolyticus*

### Virulence Properties

- ◆ The in vitro test of potential virulence for *Vibrio parahaemolyticus* is the **Kanagawa reaction**
  - most virulent strains → K<sup>+</sup> → produce a **thermostable direct hemolysin (TDH)**
  - most avirulent strains → K<sup>-</sup> → produce a **heat-labile hemolysin**
  - some strains produce both.



## Kanagawa reaction

- ◆ Kanagawa reaction:
  - use of **human red blood cells** in agar medium
  - the culture is surface plated → incubated at 37 °C for 18 – 24 hours → read for the presence of **beta hemolysis**.

Beta hemolysis ( $\beta$ -hemolysis), sometimes called complete hemolysis, is a complete lysis of red cells in the media around and under the colonies: the area appears lightened (yellow) and transparent.



## *Vibrio parahaemolyticus* Virulence Properties

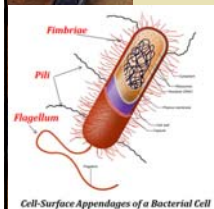
- ◆ Heat stability of TDH
  - In Tris buffer at pH 7, D 120 °C and D130 °C values of 34 and 13 minutes, respectively, were found for semi-purified toxin.
  - In shrimp D 120 °C and D130 °C values were 21.9 and 10.4 minutes, respectively.



## *Vibrio parahaemolyticus*

### Virulence Properties

- ◆ Adherence to epithelial cells is an important virulence property of G(-) bacteria
  - *V. parahaemolyticus* produces cell-associated hemagglutinins (血球凝集素) → adherence to intestinal mucosa.
  - Pili (fimbriae) also play a role in intestinal tract colonization.



Fimbriae  
繖毛  
pili 線毛



## *Vibrio parahaemolyticus*

### Gastroenteritis Syndrome and Vehicle Foods

- ◆ The mean incubation period was 16.7 hours (range, 3 –76 hours)
- ◆ Symptoms
  - lasted from 1 – 8 days, with a mean of about 4.6 days.
  - diarrhea (95%), cramps (92%), weakness (90%), nausea (72%), chills (55%), headache (48%), and vomiting (12%)



*Vibrio parahaemolyticus*  
**Gastroenteritis Syndrome and Vehicle Foods**

- ◆ **Vehicle foods**
  - **Seafood**: oysters, shrimps, crabs, lobsters, clams, and related shellfish
  - **Cross-contamination** may lead to other foods as vehicles



## **OTHER VIBRIOS**

- ◆ ***Vibrio cholerae* (霍亂弧菌)** is best known as the cause of **human cholera** contracted from **polluted water**. The classic symptom is large amounts of **watery diarrhea (水樣腹瀉)** that lasts a few days. Vomiting and muscle cramps (肌肉痙攣) may also occur. Diarrhea can be so severe that it leads within hours to severe dehydration and electrolyte imbalance.
- ◆ ***Vibrio vulnificus* (創傷弧菌)**
  - soft-tissue infections and sepsis (敗血症)



## YERSINOSIS (*Yersinia enterocolitica*, 耶爾辛氏腸炎桿菌)

- ◆ G(-) rod, motile below 30 °C but not at 37 °C
- ◆ **Growth temperature: -2 °C to 45 °C**
  - Optimum: 22 °C ~29 °C
- ◆ Addition of NaCl → raises the minimum growth temperature
- ◆ With no salt, growth was observed at 3 °C over the pH range 4.6 – 9.0
- ◆ **Destroyed in 1 – 3 minutes at 60 °C**
- ◆ Rather resistant to freezing → numbers decreasing only slightly in chicken after 90 days at -18 °C.
- ◆ **none survived after pasteurization of milk.**



## *Yersinia enterocolitica* Distribution

- ◆ widely distributed in the terrestrial (陸地上的) environment and in lake, well, and stream waters. → sources to warm-blooded animal
- ◆ *Y. enterocolitica* has been isolated from various animals such as cats, birds, dogs, rats, cattle, horses, swine, chickens, fish, and oysters.



## *Yersinia enterocolitica* *Virulence Factors*

- ◆ **heat-stable enterotoxin (ST):** survives 100 °C for 20 minutes
- ◆ ST production: ≤ 30 °C, favored in pH 7- 8.
- ◆ Although pathogenic strains produce ST, ST is not critical to virulence.
- ◆ The most significant pathogenic mechanism: **yersinia outer protein (Yop) virulon** (see Exhibit 22-3), which is also possessed in *Y. pestis* and *Y. pseudotuberculosis*. This virulon allows yersiniae to **survive and multiply in host lymphoid tissue.**



## *Incidence of Y. enterocolitica in Foods*

- ◆ Isolated from cakes, vacuum-packaged meats, seafood, vegetables, milk, beef, lamb, pork and other food products.
- ◆ **Swine** appears to be the major source of strains pathogenic to humans.



*Yersinia enterocolitica*  
*Gastroenteritis Syndrome and Incidence*

- ◆ The incidence (發生率) is highest in the very young and the old.
- ◆ In an outbreak, the symptoms (and percentage) were fever (87), diarrhea (69), severe abdominal pain (62), vomiting (56), pharyngitis (咽頭炎)(31), and headache (18). The outbreak led to two appendectomies (闌尾切除手術) and two deaths.



*Yersinia enterocolitica*  
*Gastroenteritis Syndrome and Incidence*

- ◆ **Symptoms** of the gastroenteritis syndrome develop **several days following ingestion of contaminated foods** and characterized by **abdominal pain and diarrhea**.
- ◆ Children appear to be more susceptible than adult, and the organisms may be present in stools for up to 40 days following illness.





## CAMPYLOBACTERIOSIS

(*Campylobacter jejuni* 空腸彎曲桿菌)

- ◆ *C. jejuni* is a slender, spirally curved rod that possesses a single polar flagellum at one or both ends of the cell.
- ◆ Not grow in the presence of 3.5% NaCl or at 25 °C.
- ◆ **Microaerophilic** → need 3 – 6% oxygen for growth → growth is inhibited in 21% oxygen (normally 20.9% of the gas in the atmosphere is oxygen).
- ◆ **10% carbon dioxide** is required for good growth.
- ◆ **Heat sensitive** → D 55 °C 1~3 mins
- ◆ Sensitive to freezing → number greatly reduced at -18 °C.



## CAMPYLOBACTERIOSIS

(*Campylobacter jejuni* 空腸彎曲桿菌)

### Distribution

- ◆ Not an environmental organisms → associated with **warm-blooded animals**
- ◆ A large percentage of all **major meat animals** contain these organisms in their feces, with poultry being prominent.
- ◆ The modes of pathogenesis are still unclear.



## CAMPYLOBACTERIOSIS

(*Campylobacter jejuni*)

### Enteritis Syndrome and prevalence

- ◆ Symptoms: abdominal pain or cramps, diarrhea, malaise (全身乏力), headache, and fever → lasted 1 – 4 days → In the more severe cases, **bloody stool** may occur, and the diarrhea may resemble ulcerative colitis (潰瘍性大腸炎), whereas abdominal pain may mimic acute appendicitis (急性盲腸炎).
- ◆ *Campylobacter* enteritis is considered **the leading foodborne illness in the US** (Figure 28-1).
- ◆ 90% are of food origin.



## CAMPYLOBACTERIOSIS

(*Campylobacter jejuni*) PREVENTION

- ◆ *V. parahaemolyticus*, *Y. enterocolitica*, and *C. jejuni* are all **heat-sensitive bacteria** that are destroyed by milk pasteurization temperatures.
- ◆ The **avoidance of raw seafood products** and **care in preventing cross-contamination** with contaminated raw materials will reduce the incidence of foodborne gastroenteritis caused by *V. parahaemolyticus* and *Y. enterocolitica*.



## CAMPYLOBACTERIOSIS (*Campylobacter jejuni*) PREVENTION

- ◆ To **prevent wound infections by vibrios**, individuals with body nicks or abrasions should avoid entering seawaters.
- ◆ Yersinosis can be avoided or minimized by **not drinking water that has not been purified and by avoiding raw or underprocessed milk.**
- ◆ Campylobacteriosis can be avoided by **not eating undercooked or unpasteurized foods of animal origin, especially milk.**



## Pathogens produce $\beta$ -hemolysis

- ◆ *Bacillus cereus*
  - hemolysin BL
- ◆ *Listeria monocytogenes*
  - *Listeriolysin O*
- ◆ *Vibrio parahaemolyticus*
  - thermostable direct hemolysin (TDH)



## Enterotoxins-producing pathogens

- ◆ *Staphylococcus aureus*
  - superantigen
  - overabundance of IL-2 is produced
- ◆ *Clostridium perfringens*
  - induce membrane permeability alterations
- ◆ *Bacillus cereus*
  - hemolysin BL
  - hemolysis (溶血), cytolysis (細胞溶解), dermonecrosis (皮膚壞死), vascular permeability (血管滲透性), and enterotoxic activity



## Enterotoxins-producing pathogens

- ◆ *Shigella* spp.
  - Shiga toxin inhibit mammalian protein synthesis
- ◆ Enterohemorrhagic *E. coli* (EHEC)
  - Shiga-like toxins inhibit protein synthesis
- ◆ Enterotoxigenic *E. coli* (ETEC)
  - heat-labile enterotoxin (LT) and heat-stable enterotoxin (ST)
- ◆ *Yersinia enterocolitica*
  - heat-stable enterotoxin (ST) is not critical to virulence



## Major types of foodborne diseases -- infection, intoxication, and toxin-mediated infection

### 1. Infection

- ◆ An infection is when a person eats food containing harmful microorganisms, which then grow in the intestinal tract and cause illness.
- ◆ Some bacteria, all viruses, and all parasites cause foodborne illness via infection. The foodborne bacteria that cause infection are: *Salmonella spp.*, *Listeria monocytogenes*, *Campylobacter jejuni*, *Vibrio spp.*, *Yersinia enterocolitica*, and *Escherichia coli*.



## Major types of foodborne diseases -- infection, intoxication, and toxin-mediated infection

### 2. Toxin-mediated infection

- ◆ A toxin-mediated infection is when a person eats food containing harmful bacteria. While in the intestinal tract, the bacteria produce toxins that cause illness. Some bacteria cause toxin-mediated infection. The foodborne bacteria that cause toxin-mediated infection are: *Clostridium perfringens*, *Shigella spp.*, EHEC and ETEC.



## Major types of foodborne diseases -- infection, intoxication, and toxin-mediated infection

### 3. Intoxication

- ◆ An intoxication results when a person eats food containing toxins that cause illness. Toxins are produced by harmful microorganisms, the result of a chemical contamination, or are naturally part of a plant or seafood. Some bacteria cause intoxication. Viruses and parasites do not cause foodborne intoxication. The foodborne bacteria that cause intoxication are: *Clostridium botulinum*, *Staphylococcus aureus*, and *Bacillus cereus*.