CAMPYLOBACTER JEJUNI & RELATED ORGANISMS

Historical aspects and contemporary problems

McFadyean & Stockman, British veterinarians, epizootic abortion in ewes (1909)
Theobald Smith, investigating infectious abortions of U.S. cattle (1919): *Vibrio fetus*
Jones, Little, & Orcutt, winter dysentery in U.S. calves (1931): *Vibrio jejuni*
Doyle, swine dysentery (1944)
Humans: acute milkborne diarrhea, *Vibrio jejuni* (Levy, 1946); abortion in two women, *Vibrio fetus* (Vinzent, 1947)
King (1957): *Vibrio fetus* differentiated from "related vibrios"
Sebald and Veron (1963): differentiation from cholera and halophilic vibrios ➔ genus *Campylobacter* ("curved rod")
C. jejuni and less often *C. coli* now recognized as leading (perhaps foremost bacterial) causes of diarrhea in humans; a classical zoonosis — sometimes cause animal disease, but are often a commensal in animals; numerous other pathogenic species (e.g., *C. lari*, *C. upsaliensis, C. helveticus*, etc.) described, but difficult to detect with current diagnostic methods
U.S., 1998–2002: *Campylobacter* spp. ranked #7 among total foodborne illnesses caused in recorded outbreaks for which an etiology was determined (ca. 61 outbreaks comprising ca. 1,440 cases)
CAST (1994) estimates (various sources of estimates) 170,000 to 2,100,000 cases per year, with 120 to 360 deaths — presumably all foodborne; the average medical and productivity cost per case is estimated at $920, with an annual total near $1 billion
CDC (1999) ~2 million foodborne illnesses, >10 thousand hospitalizations, 100 deaths
FoodNet (2006): second leading cause (after *Salmonella*) of diagnosed illness in study area; highest rates seen in California (Bay Area)

Characteristics of *Campylobacter*

Classification — small, nonsporeforming, gram-negative bacteria, curved, S-shaped, or spiral; 0.5–8 µm long, 0.2–0.9 µm diameter; single polar flagellum at one or both ends, rapid, darting, corkscrew-like motility; require reduced O_2 for growth (microaerophilic; aerotolerant = *Arcobacter*), increased CO_2 (capnophilic); *C. jejuni* growth optimum = 42°C, minimum 30°C, maximum ca. 45°C, thermal inactivation from 48°C, survives well at 4°C in milk and water; many species and subspecies; many serotypes of *C. jejuni*, based on somatic, capsular, and flagellar antigens
Virulence factors and their genetic basis — pathogenesis is poorly understood; both enterotoxic and enteroinvasive strains may exist
Ability to survive and grow in the environment — labile to freezing, drying, and temperatures from 48°C up; stable at 4°C, dies more quickly at 25°C than at 4° or 30°C; some losses at atmospheric levels of O_2; growth above pH 4.9, good at 5.5 to 8, optimum at 6.5–7.5; optimum salt level 0.

Nature of the infection

- Humans — unusual in affecting young adults as often as infants and elderly (fatal outcomes more common in infants, elderly, immune impaired)
  - Human disease 90% from *C. jejuni*, also *C. coli*; infectious dose is apparently "small" (<1000 organisms)
  - Incubation 2–5 (1–10) days; duration 2–5 days, sometimes 10 days; sequelae (e.g., Guillain-Barré syndrome, reactive arthritis) possible
  - Diarrhea (watery to bloody with pus & WBC), abdominal pain, malaise, fever, nausea, and vomiting; possible typhoid-like syndrome, rarely febrile convulsions, Guillain-Barré syndrome, or meningitis; may mimic acute appendicitis; many infections asymptomatic
  - Guillain-Barré syndrome is an example of "molecular mimicry;" This "mistaken immune attack" may arise because the surface of *C. jejuni* contains polysaccharides that resemble glycoconjugates of the human nerve tissues.
  - Shedding 2–7 weeks if antibiotic treatment is not done; minor source of human infection, except for an occasional food worker contaminating food
  - Lasting immunity follows infection
- Animals — frequently infected, often asymptomatically
- Reservoirs and transmission — common in cattle, swine, sheep, and especially poultry (also companion animals and rodents); carried in gall bladder and large and small intestines; shed in feces, which may contaminate edible portions of carcass; occurrence in milk may indicate shedding via the mammary gland, but mastitis is seldom involved.

Prevalence of *Campylobacter* in foods, feed, and water

- Eggs — not mentioned as a vehicle in outbreaks.
- Poultry — up to 100% positives in retail poultry (lower in some surveys), evidently due to fecal cross-contamination in post-slaughter processing.
- Meat — most common on swine carcasses; sometimes present on beef and lamb carcasses.
- Milk and milk products — readily killed by pasteurization; raw milk is a leading vehicle in U.S.
- Other foods — mainly animal products, though fertilization of vegetables with manure may cause contamination .
- Animal feed — subject to contamination from bird and rodent droppings.
- Water — caused three drinking water-associated in outbreaks in U.S., 1999–2000, from well, spring, and irrigation water (a football team in California drank irrigation water after a practice).

Foods most often associated with human infections — U.S., raw milk, poultry, other foods via cross-contamination

Principles of detection of *Campylobacter*

Samples ideally stored at 4°C in a N_2 atmosphere, with 0.01% sodium bisulfite added.
Expect low contamination levels: pre-enrichment likely to be necessary.
This is a slow-growing organism, so isolation medium must be selective, to inhibit competitors.
Optimum atmosphere is 5% O_2, 10% CO_2, 85% N_2; candle jars are marginally useful.
Incubation generally 42°C
Antibiotics used in some selective media may inhibit some strains of *C. jejuni*, also *C. coli*; cefaperazone is presently recommended, to the exclusion of cephalothin.
Identification: gram-negative, appropriate appearance, growth at appropriate temperature in appropriate atmosphere; oxidase and catalase positive; hydrolyzes hippurate and indoxyl acetate; reduces nitrate; produces H_2S; tests for some of these properties require special precautions; membrane filtration exploits the small size and motility of *Campylobacter* spp. (especially useful for less common species that are susceptible to selective antibiotics used for *C. jejuni/C. coli* isolation).
Nonculture detection methods (e.g., PCR) and epidemiologic typing systems are available (PFGE, MLST).

Related organisms:

Arcobacter (1991,1992) — first differentiated as "aerotolerant *Campylobacter*"; grow at 15, 25, and 30°C, but variably at 37 and 42°C; similar appearance (gram negative, curved, S-shaped, or helical; single polar flagellum, 1–3 µm long, 0.2–0.9 µm diameter; may grow aerobically at 30°C and anaerobically at 35–37°C.
"Frequently isolated from cattle and pigs suffering from abortion and enteritis"
Human illnesses from two of the species include bacteremia, endocarditis, peritonitis, and diarrhea.
An 8-year study by Vandenberg et al (2004) found *Arcobacter butzleri* was the fourth most common *Campylobacter*-like organism isolated from 67,599 stool specimens in Belgium; observations suggest that *A. butzleri* displays microbiologic and clinical features similar to those of *Campylobacter jejuni; A. butzleri* was more frequently associated with a persistent, watery diarrhea.
Emerging infection?

Helicobacter pylori — discovered in 1982, separated from genus *Campylobacter* in 1989; looks like *Campylobacter*, microaerophilic, optimum growth at 37°C; culture characteristics, etc., need not be discussed here.
Clinically important as probable cause of chronic gastritis and peptic and duodenal ulcer in humans
Human infection is widespread (nonhuman reservoirs of this species unknown); shed with feces and may contaminate food, but foodborne transmission is not clearly

established.

Bibliography

Altekruse, S., and G. I. Perez-Perez. 2006. *Campylobacter jejuni* and related organisms, pp. 259–287. *In* Riemann, H. P., and D. O. Cliver, eds. 2006. Foodborne Infections and Intoxications, 3d ed. Academic Press (Elsevier), London, Amsterdam.

Altekruse, S., and D. L. Swerdlow. 2002. *Campylobacter jejuni* and related organisms. pp. 103–112. *In* D. O. Cliver and H. P. Riemann, eds. Foodborne Diseases, 2d ed., Academic Press, London.

Blackburn, B. G., et al. 2004. Surveillance for waterborne-disease outbreaks associated with drinking water — United States, 2001–2002. Morbid. Mortal. Wkly. Rep. 53(SS-8):23–45.

Centers for Disease Control and Prevention. 2007. Preliminary FoodNet data on the incidence of infection with pathogens transmitted commonly through food— 10 sites, United States, 2006. Morbid. Mortal. Wkly. Rept. 56:336–339.

Council for Agricultural Science and Technology (CAST) 1994. Foodborne pathogens: risks and consequences. Task Force Report No. 122, CAST, Ames, IA.

Heyman, D. L., ed. 2004. Control of Communicable Diseases Manual, 18th ed. American Public Health Association, Washington, DC.

Jerris, R. C. 1995. *Helicobacter*. pp. 492–498. *In* P. R. Murray, E. J. Baron, M. A. Pfaller, F. C. Tenover, and R. H. Yolken (eds), Manual of Clinical Microbiology, 6th ed. American Society for Microbiology Press, Washington, DC.

Lynch, M., Painter, J., Woodruff, R., and Braden, C. 2006. Surveillance for foodborne-disease outbreaks ─ United States, 1998−2002. Morbid. Mortal. Weekly Rep. Surveillance Summaries 55(SS-10):1−34.

Mead, P. S., L. Slutsker, V. Dietz, L. F. McCaig, J. S. Bresee, C. Shapiro, P. M. Griffin, and R. V. Tauxe. 1999. Food-related illness and death in the United States. Emerging Infect. Dis. 5:607–625.

Miller, W.G., On, S.L., Wang, G., Fontanoz, S., Lastovica, A.J., and Mandrell, R.E.. 2005. Extended multilocus sequence typing system for *Campylobacter coli, C. lari, C. upsaliensis,* and *C. helveticus*. J. Clin. Microbiol. 43:2315–2329.

Nachamkin, I. 1995. *Campylobacter* and *Arcobacter*. pp.483–491. *In* P. R. Murray, E. J. Baron, M. A. Pfaller, F. C. Tenover, and R. H. Yolken (eds), Manual of Clinical Microbiology, 6th ed. American Society for Microbiology Press, Washington, DC.

Nachamkin, I. 2001. *Campylobacter jejuni*. pp. 179–192. *In* M. P. Doyle, L. R. Beuchat, and T. J. Montville, eds., Food Microbiology: Fundamentals and Frontiers, 2d ed. ASM (American Society for Microbiology) Press, Washington, DC.

Palumbo, S., C. Abeyta, G. Stelma, I. W. Wesley, C.-i. Wei, J. A. Koberger. S. K. Franklin, L. Schroeder-Tucker, and E. A. Murano. 2001. *Aeromonas*, *Arcobacter*, and *Plesiomonas*. pp. 283–300. *In* F. P. Downes and K. Ito, eds., Compendium of Methods for the Microbiological Examination of Foods, 4th ed. Am. Pub. Health Assoc., Washington, DC.

Stern, N. J., J. E. Line, and H.-C. Chen. 2001. *Campylobacter*. pp. 301–309. *In* F. P. Downes and K. Ito, eds., Compendium of Methods for the Microbiological Examination of Foods, 4th ed. Am. Pub. Health Assoc., Washington, DC.

Vandenberg, O., Dediste, A., Houf, K., Ibekwem, S., Souayah, H., Cadranel, S., Douat, N., Zissis, G., Butzler, J.P., and Vandamme, P. 2004. *Arcobacter* species in humans. Emerg. Infect. Dis. 10:1863–1867.