Arcobacter: An Overview

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Introduction

The genus *Arcobacter* (Latin, arc-shaped bacterium) includes bacteria formerly designated *Campylobacter cryaerophila* (Latin; loving cold and air). They are fastidious, microaerophilic, gram-negative, spiral-shaped-bacteria that are motile by means of polar flagella. *Arcobacter* was first isolated by Ellis et al (6) in 1977 from aborted bovine and later from porcine fetuses. Unlike other *Campylobacter* species, *Arcobacter* grows in the presence of atmospheric oxygen (aerotolerant) and at 15°/C, which is lower than temperatures used for incubation of *Campylobacter* (21,22).

Arcobacter spp. have been associated with cases of human enteritis and septicemia (12, 13, 27, 28, 29,30); enteritis and abortion occur in livestock (6,21,22,23,24). *Arcobacter* spp. have been found in water, cattle, swine, poultry, and in ground pork and turkey products. *Campylobacter jejuni* is a major cause of human bacterial enteritis. Because of their phylogenetic similarity, the pathogenesis, distribution and routes of transmission that have been described for *C. jejuni* may be applicable to *Arcobacter*. Transmission of *C. jejuni* to humans occurs via consumption of contaminated undercooked poultry, water, raw milk, milk that has been contaminated after pasteurization, shellfish, and meat.

Three species of *Arcobacter* have been recovered from man and animals: *A. butzleri, A. cryaerophilus*, and *A. skirrowii* (31,32). Of these, *A. butzleri* is regarded as the primary human pathogen (12).

Herein we provide a review of *Arcobacter* and address the possibility of considering *Arcobacter* spp., especially *A. butzleri*, as emerging foodborne pathogens.

Results and Discussion

Figure 1 summarizes the current knowledge regarding the presence of *Arcobacter* in food animals and in foods. *Infections in humans and animals*. Arcobacter infections in animals are associated with abortions and enteritis (37). Enteritis and occasionally septicemia occur in humans (13, 27, 28, 30). Primates naturally infected with *Arcobacter* develop colitis, which may provide insight into its pathogenesis in humans (1).

For cattle, *Arcobacter* spp. have been reported in the feces of calves with diarrhea, cows with mastitis (15), as well as from clinically healthy animals. We have developed a rapid method to detect *Arcobacter*, which involves enrichment in Ellinghausen McCullough, Johnson, and Harris (EMJH-P80) semisolid media, incubation (30°C, 1 week), followed by polymerase chain reaction (PCR) screening (10). Using this method, we detected *Arcobacter* in 11% of fecal samples from normal dairy cattle (n=1,236).

Arcobacter is present in both healthy pigs and in aborted porcine fetuses (7, 22, 23,37). We have cultured significantly more (P<0.00 1) *Arcobacter* from aborted porcine fetuses than from fetuses obtained from a slaughterhouse. Despite the association of *Arcobacter* with porcine abortions, no differences were seen in the recovery of *Arcobacter* spp. from rectal, preputial, or vaginal swabs taken from pigs from a herd with reproductive problems versus a herd of specific pathogen-free animals. By enrichment in EMJH-P80 followed by PCR, we detected *Arcobacter* spp. in 40% of fecal samples of clinically healthy pigs. We have experimentally infected caesarean-derived colostrum-deprived piglets with *Arcobacter* spp. and have shown that *A. butzleri*, like *C. jejuni* and colonizes neonatal piglets. This suggests its invasive potential (36). In vitro studies using HEp-2 cells likewise have indicated its potential virulence (9).

Detection in foods-In beef products, *Arcobacter* spp. have been cultured in 1. 5% of minced beef (n=68) samples examined in The Netherlands (5). No studies to date have reported the distribution of *Arcobacter* in fresh ground beef in the U.S.

Its recovery in hogs and susceptibility of piglets to infection suggest a possible association of *Arcobacter* spp. with pork products. Collins et al. (3) detected *Arcobacter* in 54% of ground pork samples (n=289) obtained from five slaughter plants. Recoveries ranged from 0% to 89%. It was not determined whether management practices at the source farms or the sanitary conditions at slaughter influenced the prevalence of *Arcobacter* spp. in ground pork. However, using an *Arcobacter* Selective Broth and Medium, deBoer et al., isolated the organism in only 0.5% (1 of 194) of pork cuts purchased in the Netherlands (5). The difference between ground pork and minimally processed pork cuts as well as isolation methods may explain these differences.

Arcobacter, like *Campylobacter*, has been reported more frequently from poultry than from red meats (34). Thus, poultry may be a significant reservoir of *A. butzleri*. In France, *A. butzleri* was recovered from 81% of poultry carcasses examined (n=201). Nearly half of the poultry isolates in that study were of serogroup 1. Serogroups 1 and 5 are primarily associated with human infection (8,18). In a survey of poultry products in Canada, *A. butzleri* was cultured from 97% (121 of 125) of poultry carcasses obtained from five different processing plants. In addition, *A. butzleri* was cultured from retail-purchased whole and ground chicken and turkey samples. As was the case in the French study, serotype 1 was the predominant serotype isolated from Canadian poultry (17). We utilized EMJH P80 enrichment in combination with PCR11 to determine the prevalence of *Arcobacter* in mechanically separated turkey samples obtained from three processing plants in the U.S. Of 395 samples examined, 77% (303 of 395) were positive for *Arcobacter*. *Arcobacter butzleri* was detected in 56% of samples (223 of 395) (19). In contrast to the recoveries from poultry which were reported from France, Canada, and the U. S., *Arcobacter* was detected in only 24% (53 of 224) of

retail purchased poultry in the Netherlands (5). The differences in recovery rates could be due to hygienic conditions in each abattoir or processing plant ,as well as to differences in the sensitivity of isolation methods. Despite repeated attempts, we have not established *Arcobacter* experimental infections in 3-day-old chicks. Nevertheless, on-farm studies to determine the carrier rate of poultry are needed.

The distribution of *Arcobacter* spp. in seafoods, shellfish, and raw milk is unknown.

The presence of *A. butzleri* in poultry and meats, especially ground pork, prompted studies to determine its sensitivity to irradiation (4). By comparing D_{10} values (the irradiation dose that reduces by 10-fold the number of viable bacteria), *A. butzleri* (0.27 kGy) was found to be more resistant to irradiation than *C. jejuni* (0.18 kGy). Thus, proposed irradiation doses (1.5 to 4.5 kGy), which are under review by the U. S. Food and Drug Administration, would eliminate *Campylobacter* as well as *Arcobacter* from ground pork (4).

Transmission of *A. butzleri* may involve drinking contaminated water (8,16). *Arcobacter* spp. may be more common in developing nations with inadequate water supplies since *A. butzleri* accounted for 16% of the *Campylobacter*-like isolates made from cases of diarrhea in Thai children (28). *Arcobacter butzleri* has been cultured from rivers (20), canals of Bangkok (34), and drinking water reservoirs in Germany (16).

Isolation methods and species identification. The morphologic similarity between *Arcobacter* and *Campylobacter* may confound correct identification. A key feature to distinguish *Arcobacter* spp. from other *Campylobacter* spp. is the lower temperatures (15°C-30°C) which are utilized for initial isolation (22). Whereas *C. jejuni*, *C. coli*, or *C. lari* grow optimally at 42°C, few *Arcobacter* display this thermotolerance.

There is no standard method for the isolation of *Arcobacter* spp., which restricts comparison of field studies. *Arcobacter* spp. were first isolated by using EMJH-P80 semi solid media originally designed for *Leptospira* (22). Modifications of methods defined for *Campylobacter*, but at lower incubation temperatures also have been used (17). A comparison of each method's sensitivity is needed. Biochemical tests to phenotype *Arcobacter* species are limited (13, 21, 25, 26, 32). All isolates hydrolyze indoxyl acetate. The catalase test can distinguish between the two species of clinical and veterinary interest: *A. butzleri* exhibits a weak catalase reaction whereas that of *A. cryaerophilus* is strong (13, 32).

The species of *Arcobacter* are distinguished by restriction fragment length polymorphisms (ribotyping). For ribotyping, chromosomal DNA is extracted, cut with a restriction enzyme, and hybridized with 16S rDNA probes. The resultant DNA pattern or ribotype of *A. butzleri* differs from that of *A. cryaerophilus* and thus can be used for speciation (14, 26, 35).

PCR assays to detect all members of the genus *Arcobacter* (10) and that are specific for each *Arcobacter* species have been reported (2). A multiplex PCR assay to simultaneously identify *Arcobacter* and *A. butzleri* in livestock and foods has been described (11). DNA-based fingerprinting may provide insight into the source of *Arcobacter* contamination. In a 1993 study, PCR-mediated DNA fingerprinting confirmed the identity of *A. butzleri* isolates recovered from a nursery school outbreak, suggested person-to-person transmission, and implicated a single source of contamination (33). In contrast, we used DNA probes and PCR fingerprinting to study over 121 *A. butzleri* field strains recovered from mechanically separated turkey meat. The presence of multiple fingerprints indicated numerous sources of contamination (19).

Conclusion

Arcobacter spp. are found in livestock, meat, and in water. As summarized in Figure 1, *Arcobacter* spp. have been described in cattle and beef, and in pigs and pork products. Although they have been recovered from poultry, the incidence of *Arcobacter* spp. in live birds is unknown. Earlier reports described *A. skirrowii* in lambs, but whether it is present in lamb products is unknown. The current availability of DNA-based methods will further contribute to understanding the basic epidemiology of *A. butzleri* and thus elucidate its potential as a human foodborne agent.

References

1. Anderson, K.F. et al, 1993. *Arcobacter (Campylobacter) butzleri*-associated diarrheal illness in a nonhuman primate population. Infect. Immun. 61:2220-2223.
2. Bastyns, K.et al, 1995. A variable 23S rDNA region is a useful discriminating target for genus-specific and species-specific PCR amplification in *Arcobacter* Species. Syst. Appl. Microbiol. 18: 353-356.
3. Collins, C.I. et al, 1996. Detection of *Arcobacter* spp. in ground pork by modified plating methods. J. Food Prot. 59, 448-452.
4. Collins, C.I.et al, 1996. Survival of *Arcobacter butzleri* and *Campylobacter jejuni* after irradiation treatment in vacuum packaged ground pork. J. Food Prot. 59, 1164-1166.
5. de Boer, E. et al, 1996. A selective medium for the isolation of A*rcobacter* from meats. Lett. Appl. Microbiol. 23, 65-66.
6 Ellis WA et al, 1977. Isolation of Spirillum/Vibrio-like organisms from bovine fetuses. Vet. Rec. 100:4351-452.
7. Fernandez H et al, 1995. Primer aislamiento de A*rcobacter cryaerophilus* a partis de un aborto bovino en Chile. Arc. Med. Vet. XXVIII:111-114.
8. Festy B et al, 1993. Poultry meat and water as the possible sources of *Arcobacter butzleri* associated with human disease in Paris, France. Acta Gastro-Enterologica Belgica 56 (suppl):35.
9. Fernandez H et al, 1995. Toxigenic and invasive capacities: Possible pathogenic mechanisms in *Arcobacter* c*ryaerophilus* Mem. Inst .Oswaldo Cruz, 90:633-634.
10. Harmon, K.M. et a1, 1996. Identification of *Arcobacter* isolates by PCR. Lett. Appl. Microbiol. 23, 241-244.
11. Harmon, K.M. et al, 1997. Multiplex PCR for the identification of *Arcobacter* and differentiation of *Arcobacter butzleri* from other *arcobacters*. Vet. Micro. (In press).
12. Hsueh, P.R. et al, 1997. Bacteremia caused by *Arcobacter cryaerophilus* 1B. J. Clin. Microbiol. 35:489-491.

13. Kiehlbauch, J.A.et al., 1991. *Campylobacter butzleri* sp. nov. Isolated from humans and animals with diarrheal illness. J. Clin. Microbiol. 29, 376-385.
14 Kiehlbauch, J.A. et al., 1991. Restriction fragment length polymorphisms in the ribosomal genes for species identification and subtyping of aerotolerant *Campylobacter* species. J. Clin. Microbiol. 29: 1670-1676.
15. Logan, E.F. et al, 1982. Mastitis in dairy cows associated with an aerotolerant *Campylobacter*. Vet. Rec. 110:229-230.
16. Jacob, J. et al., 1993. Isolation of *Arcobacter butzleri* from a drinking water reservoir in Eastern Germany. Zentralblatt fur Hygiene, 193: 557-562.
17. Lammerding, A., 1997. Isolation Method for Recovery of *Arcobacter butzleri* from fresh poultry and poultry products. *Campylobacter* VIII (Newall, D.G. and Ketley, H.J., eds.), Plenum Publ. Corp. (in press)
18. Lior, H. J. et al., 1993. *Arcobacter butzleri*:A serotyping scheme. Acta Gastro-Enterologica Belgica 56: (Suppl):29:
19. Manke TR. 1997. A survey of mechanically separated turkey for the presence of *Arcobacter* spp. and *Arcobacter butzleri* and the genetic variability of *Arcobacter butzleri* isolates. MS Thesis, Iowa State University, Ames, Iowa.
20. Musmanno, R.A. et al., 1997. In vitro virulence factors of *Arcobacter butzleri* strains isolated from superficial water samples. Microbiologica 20:673-68.
21. Nachamkin, I., 1995. *Campylobacter* and *Arcobacter*, p, 483-491 In A. Balows WJ Hausler Jr, KL Hermann and DH Isenberg (ed). Manual of clinical microbiology, 6th ed. American Society for Microbiology, Washington, DC.
22. Neill, S.D. et al., 1985. Taxonomic Position of *Campylobacter cryaerophila* sp. nov. Int. J. Syst. Bacteriol. 35: 342-356
23. de Oliveira, S. J., et al. 1995. Isolamento de *Arcobacter cryaerophila* de fetos suinos abortados. Ciencia Rural, Santa Maria 25:171-172.
24. de Oliveira, S. J., et al. 1997. Classification of *Arcobacter* species isolated from aborted pig fetuses and sows with reproductive problems in Brazil . Vet. Microbiol. (accepted)
25. On, S.L., 1996. Identification methods for *campylobacters, helicobacters,* and related organisms. Clin. Microbiol. Rev. 9:405-422.
26. Schroeder-Tucker, L., et al 1996). Phenotypic and ribosomal RNA characterization of *Arcobacter* species isolated form porcine aborted fetuses. J. Vet. Diagn. Invest. 8: 186-195.
26. Skirrow, M. B., 1994. Diseases due to *Campylobacter*, H*elicobacter* and related bacteria. J Comp path. 111:113-149.
27. Taylor, D. N., et al., 1991. Isolation of group 2 *Campylobacter* species from Thai children with diarrhea. J. Infect. Dis. 163:1062-1067.
28. Tee, W., et al 1988. *Campylobacter cryaerophila* isolated from a human. J. Clin. Microbiol. 26:2469-2473.
29. Vandamme, P et al.,1991a. Outbreak of recurrent abdominal cramps associated with *Arcobacter butzleri* in an Italian school. J. Clin. Microbiol. 30:2335-2337.
30. Vandamme, P.et al., 1991. Revision of *Campylobacter, Helicobacter*, and Wolinella Taxonomy: Emendation of generic descriptions and proposal of *Arcobacter* gen. nov. Int. J. Syst. Bacteriol. 41, 88-103.
31. Vandamme, P.et al. 1992. Polyphasic taxonomic study of the emended genus *Arcobacter* with *Arcobacter butzleri* comb. nov. and *Arcobacter skirrowii* sp. nov., an aerotolerant bacterium isolated from veterinary specimens. Int. J. Syst. Bacteriol. 42: 344-356.
32. Vandamme, P. et al., 1993. Discrimination of epidemic and sporadic isolates of *Arcobacter butzleri* by polymerase chain-reaction-mediated DNA fingerprinting. J. Clin. Microbiol. 31, 3317-3319.
33. Wesley, I.V. 1996. *Helicobacter* and *Arcobacter* species: Risks for foods and beverages. J. Food Prot. 59, 1127-1132
34. Wesley, I.V.et al., 1995, Oligonucleotide probes for the genus *Arcobacter* and for *Arcobacter butzleri* based on 16S rRNA sequence. J. Clin. Microbiol. 77, 1691-1698.
35. Wesley, I.V., et al., 1995. Infection of Cesarean-derived colostrum-deprived l-day-old piglets with *Arcobacter butzleri, Arcobacter cryaerophilus,* and *Arcobacter skirrowii.* Infect. Immun. 64, 2295-2299
36. Wesley, I.V.,1994. *Arcobacter* Infections' in Handbook of Zoonoses (Beran, G.W. and Steele, J.H. eds.), pp. 181-190, CRC Press, Boca Raton, Florida.

Figure 1. Summary of distribution of *Arcobacter* in livestock species and the respective food product. A **(+)** indicates that *Arcobacter* has been recovered from live hogs, and cattle as well as from retail purchased pork and poultry. A **(?)** indicates insufficient data available to determine the distribution of *Arcobacter* in live poultry, and retail purchased beef or lamb products.