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Desulfovibrio desulfuricans Bacteremia and Review of Human *Desulfovibrio* Infections

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One case of primary *Desulfovibrio desulfuricans* bacteremia in an immunocompetent man is presented, and 15 other reported cases are reviewed. While most isolates have not been identified to the species level, *Desulfovibrio fairfieldensis* and *D. desulfuricans* have been associated with incidents of bacteremia and *D. vulgaris* has been associated with intra-abdominal infections. In vitro studies suggest that empirical therapy with either imipenem or metronidazole should be considered.

Desulfovibrio organisms belong to a heterogeneous group of sulfate-reducing, motile, anaerobic bacteria with more than 30 proposed species, some of which infrequently cause a variety of human infections (*D. desulfuricans*, *D. vulgaris*, *D. salexigens*, *D. africanus*, *D. gigas*, *D. baculatus*, *D. sapovorans*, *D. baarsii*, *D. thermophilus*, *D. fairfieldensis*, *D. gabonensis*, *D. piger*, *D. profundus*, *D. aosterae*, *D. burkinensis*, *D. longus*, *D. orale*, *and D. aespoeensis*). The bacteria may be carried asymptomatically in the human gastrointestinal tract (1), or they may act as opportunistic pathogens associated with primary bacteremia and abdominal infections, such as abscess and cholecystitis (Table 1). Gibson et al. (3) postulated a role for *Desulfovibrio* in ulcerative colitis. The bacteria are ubiquitous in nature and can be found in the gastrointestinal tracts of animals such as sheep, dogs, pigs, hamsters, and ferrets (2), and they have been cultured from a variety of environmental samples, including mud, brackish water, sewage, and industrial and freshwater sediments (1, 4). These organisms often grow slowly, taking from 4 to 7 days to appear on an agar surface, are difficult to identify, and are frequently overlooked because of overgrowth in mixed cultures; consequently, their incidence in human disease may be underestimated and is certainly underreported. This article reports a case of *D. desulfuricans* bacteremia in an otherwise healthy man and reviews the characteristics and therapy of 15 previously reported, similar cases.

Case report. A 64-year-old man was admitted to the hospital with headache, severe malaise, and a fever of 101°F. The patient had traveled for 1 month to southern France, Spain, and Portugal. On the day of his return flight from Paris to Los Angeles, he experienced a single episode of severe diarrhea. During the week after his return to Los Angeles, he traveled to Yosemite National Park and played several rounds of golf at local courses. He had no significant animal contact. A physical examination found the patient's condition to be normal, with the exception of a temperature of 101°F. There were no associated rigors or other symptoms except malaise and tinnitus. The white blood cell count was 8,600 per mm^3, with a differential that included 16% band forms. His hematocrit was 41.9%, and his platelet count was 151,000 per mm^3. The patient was treated empirically with 100 mg of doxycycline administered intravenously twice daily, and he became afebrile after 24 h. Tests for brucellosis, leptospirosis, syphilis, and borrelliosis were negative. The patient was discharged on the third hospital day, completed a 21-day course of doxycycline, and recovered uneventfully.

The two sets of blood cultures collected by the emergency department were flagged positive by the BACTEC 9240 blood culture system (Becton Dickinson) in anaerobic Lytic-10 medium after 60 h of incubation. Gram stains revealed gram-negative spiral bacilli, and wet mounts made from centrifuged concentrates showed that the organisms were motile. The contents of positive vials were subcultured to chocolate and blood agars incubated at 35°C in 6% CO_2, to MacConkey agar incubated aerobically at 35°C, and to CDC anaerobic blood agar incubated anaerobically at 35°C. After 4 days, small translucent colonies appeared on the anaerobic media; the aerobic plates remained negative. The isolate was sent to the R. M. Alden Research Laboratory for identification. It was categorized as a *Desulfovibrio* species on the basis of morphology, motility, obligate anaerobic requirements, the lack of saccharolytic activity, a positive desulfoviridin test, and the production of H_2S (5). Identification of the species was performed by Quest Diagnostics (San Juan Capistrano, Calif.) with a MicroSeq 500 16S ribosomal DNA sequencing kit (Applied Biosystems, Foster City, Calif.), which sequences the first 500 bp of the 16S rRNA gene. The DNA was first amplified by PCR, purified, and then sequenced by the dideoxy chain termination cycle sequencing method. The sequenced products were purified and resolved by capillary electrophoresis on an ABI 3700 DNA sequencer and analyzed with ABI Sequencing Analysis software. The resulting DNA sequence was compared by means of MicroSeq analysis software to Applied Biosystem's library of 16 ribosomal DNA bacterial sequences. In addition, the sequences were also compared against those in public databases. The isolate was identified as *D. desulfuricans.*

Our isolate was beta-lactamase positive (per testing with nitrocefin), and the indicated MICs of the following antimicrobial agents for this isolate were determined by using the NCCLS agar dilution method (11): penicillin, >4 μg/ml;

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TABLE 1. Characteristics of 16 cases of *Desulfovibrio* infections in humans[a]

Case no.	Source	Isolate	Infection	Presence of other isolates	Therapy	Reference
1	Blood	*D. desulfuricans*	Sepsis, cholecystitis	UNK	UNK	12
2	Peritoneal fluid	*D. vulgaris*	Abdominal abscess	No	UNK	4
3	Pus	*D. fairfieldensis*	Liver abscess	Yes	CTX, MTZ, AMP, CIP	15
4	Peritoneal fluid	*Desulfovibrio* sp.	Appendicitis	UNK	UNK	1
5	Peritoneal fluid	*Desulfovibrio* sp.	Appendicitis	UNK	UNK	1
6	Blood	*D. fairfieldensis*	Polyps	No	CIP	10
7	Urine	*D. fairfieldensis*	Meningoencephalitis	No	AMP, RIF	6
8	Pus	*Desulfovibrio* sp.	Brain abscess	Yes	CTX, PIP	9
9	Pus	*Desulfovibrio* sp.	Brain abscess	Yes	UNK	7
10	Pus	*Desulfovibrio* sp.	Appendix abscess	Yes	UNK	7
11	Pus	*Desulfovibrio* sp.	Peritonitis, abscess	Yes	UNK	7
	Blood	*Desulfovibrio* sp.		Yes	UNK	
12	Blood	*D. fairfieldensis*	Appendicitis	No	UNK	7
13	Abdominal abscess	*Desulfovibrio* sp.	Abscess	Yes	UNK	7
14	Blood	*Desulfovibrio* sp.	Abdominal abscess	Yes	UNK	7
15	Abdominal abscess	*Desulfovibrio* sp.	Abscess	Yes	UNK	7
16	Blood	*D. desulfuricans*	Sepsis	No	DOX	This study

[a] UNK, unknown; CTX, cefotaxime; MTZ, metronidazole; AMP, ampicillin; CIP, ciprofloxacin; RIF, rifampin; PIP, piperacillin; DOX, doxycycline.

amoxicillin-clavulanate, 0.5 μg/ml; ampicillin-sulbactam, 1.0 μg/ml; piperacillin-tazobactam, 64/4 μg/ml; ticarcillin-clavulanate, 2/2 μg/ml; ceftriaxone, 16 μg/ml; cefoxitin, >128 μg/ml; levofloxacin, 0.5 μg/ml; moxifloxacin, gatifloxacin, and metronidazole, 0.125 μg/ml; clindamycin, 0.25 μg/ml; chloramphenicol, 8 μg/ml; and imipenem and ertapenem, 0.25 μg/ml. By the Etest, doxycycline had an MIC of 0.38 μg/ml for the isolate. The Etest was used for doxycycline because we did not have powder for the agar dilution test. The Etest was easy to read and could be used to test other agents as needed.

Desulfovibrio is infrequently the cause of human or veterinary infection (2, 4, 6, 7, 9, 10, 12, 13, 14, 15). To date, this organism has been found to have been the sole isolate in five cases of bacteremia. In three of these cases, the organism was determined to be *D. fairfieldensis*, in one case the organism was *D. desulfuricans*, and in one case the organism was identified only to the genus level. One of the cases of bacteremia was associated with a multibacterial abdominal infection from which a genetically identical *D. fairfieldensis* strain. Most reports do not identify the species, so scant data on the relative rates of occurrence of the different *Desulfovibrio* species are available. Loubinoux et al. (7) have suggested that while *Desulfovibrio* may be a weak, opportunistic pathogen, it appears that *D. fairfieldensis* "may possess a higher pathogenic potential than other *Desulfovibrio* species" since it has accounted for the majority of monobacterial isolations, mostly from bacteremic cases. Our case is the second report of *D. desulfuricans* bacteremia as a monobacterial infection, which suggests that this species also exhibits pathogenic potential. Eight of the 16 isolates (50%) have been obtained from patients with appendicitis and/or intra-abdominal abscesses, and in six other cases, the suspected source was an intra-abdominal process. Our case was associated with a diarrheal disease that occurred approximately 10 days prior to the onset of illness, but no gastroenterological symptoms were present immediately prior to the bacteremia, which suggests that there was a possible intestinal colonization and subsequent invasion.

One case of *D. desulficans* bacteremia was reported for a 2.5-year-old Labrador retriever with a fever of 105°F, anorexia, a tense abdomen, and rear-limb stiffness (14). The dog was treated and cured with doxycycline. An abdominal source of infection was suspected but not proven.

The optimal antimicrobial therapy for *Desulfovibrio* infection remains undetermined. In the cases reported, diverse therapeutic regimens have been used. Patients have been treated with multiple antimicrobials, including metronidazole, doxycycline, ceftriaxone, cefotaxime, ciprofloxacin, and ampicillin. Lozniewski et al., using an agar dilution method with supplemented Brucella agar as the basal medium and reading the results at 48 h (8), reported the in vitro susceptibilities of 16 clinical isolates of *Desulfovbrio* species. Loubinoux et al. (7) used Wilkins-Chalgren agar and read results at 96 h because of the "slow growth of the organism." They noted that all isolates were susceptible to imipenem (MIC at which 90% of the isolates were inhibited, 0.5 μg/ml; range, 0.125 to 1 μg/ml) and metronidazole (MIC at which 90% of the isolates were inhibited, 0.25 μg/ml; range, 0.125 to 1 μg/ml) but that penicillin G, piperacillin (with and without tazobactam), and cefoxitin were "devoid of significant antimicrobial activity." Six isolates had a positive nitrocefin test, which suggests that class A beta-lactamase may be produced in some strains but that more than one mechanism of beta-lactamase resistance may be operative. Most isolates were susceptible to ciprofloxacin, chloramphenicol, and clindamycin. Our patient was treated empirically with doxycycline, to which the isolate was susceptible, and had a good response, as did the Labrador retriever (14). Lozniewski et al. (8) suggested that either imipenem or metronidazole should be the agent of choice to treat infections with *Desulfovibrio* spp., especially as these species were often isolated from mixed aerobic-anaerobic infections.

Motile, strictly anaerobic gram-negative rods are infrequently encountered in clinical specimens, especially in blood cultures. Several isolates of *Anaerobiospirillum succiniciproducens* have been referred to our lab during the past 20 years. These bacteria have a corkscrew shape and a jerky motility; ferment glucose, maltose, lactose, and sucrose; are desulfoviridin negative; and are sensitive to the 10-μg colistin disk. *Desulfovibrio* spp. are curved rods with a rapid, progressive mo-

tility; they are resistant to colistin, asaccharolytic, and, most importantly, desulfoviridin positive. Other saccharolytic, desulfoviridin-negative motile genera include *Butyrivibrio*, *Succinimonas*, *Succinivibrio*, *Anaerovibrio*, and *Selenomonas.* Asaccharolytic, desulfoviridin-negative genera include *Wolinella* and *Campylobacter*. Growth of the species of these two genera is stimulated by the addition of a formate-fumarate supplement to the broth media (5).

Desulfovibrio infections are an infrequent cause of human disease and are often associated with an intra-abdominal source. Empirical antimicrobial therapy with either imipenem or metronidazole should be considered.

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