and splenectomy. One adult developed *Aeromonas* postcraniotomy meningitis. Seizures occurred in the four patients who were two years of age or younger. The organism was isolated from five of seven cerebrospinal fluid cultures and all blood cultures. Three patients died.

Four neonates with *Plesiomonas* meningits have been described[3]. All were apparently healthy at birth but became ill within the first four days of life. Three developed seizures and all four died by the fifth day of life.

Cutaneous infections. Both immunocompetent and immunocompromised hosts can develop *Aeromonas* wound infections. Exposure of wounds to presumably contaminated water has been noted in about half the cases. The infection progresses rapidly over a few hours in many individuals and may be accompanied by fever and leukocytosis. Gas formation suggestive of clostridial disease has been noted in some *Aeromonas*-infected wounds. Ecthyma gangrenosum, previously believed to be pathognomonic of *Pseudomonas* sepsis, occurs in about 10% of patients with malignancies complicated by *Aeromonas* sepsis[7]. Bacteremia may also follow a primary *Aeromonas* or *Plesiomonas* wound infection[3,6]. Patients with cutaneous *Aeromonas* infections have been treated with antibiotics, surgical debridement, or both. The response to therapy was usually good but three patients with severe disease required amputation of infected limbs[6].

Musculoskeletal infections. Necrotizing *Aeromonas* myositis may result from a penetrating injury or from hematogenous spread of the organism and has been described in 14 patients[6]. Therapy consisted of antibiotics with or without surgical debridement. Amputation of the affected limb was required in four patients. Eight (57%) patients died.

Suppurative arthritis has been described in three patients with leukemia and *Aeromonas* sepsis[6], none of whom was in remission, and in one elderly patient with rheumatoid arthritis and *Plesiomonas* sepsis[3]. Three patients had knee arthritis and the fourth developed infection of a metacarpophalangeal joint during the course of *Aeromonas* sepsis with multisystem involvement. The organisms could be isolated from blood and synovial fluid cultures in all cases. All four patients died. *Aeromonas* osteomyelitis may follow trauma or bacteremia and has been documented in eight patients[6]. Lower extremity bones are the ones typically involved.

Miscellaneous infections. Pulmonary disease may occur during the course of *Aeromonas* sepsis or as aspiration pneumonia in patients with near-drowning. *Aeromonas* peritonitis may complicate intestinal perforation or peritoneal dialysis but can also arise as a spontaneous bacterial infection in patients with hepatic cirrhosis. Several cases of acute cholecystitis with or without ascending cholangitis due to *Aeromonas* have been reported[6] but only two caused by *Plesiomonas*[2,11]. Ocular *Aeromonas* infections manifesting as corneal ulcers or conjunctivitis are usually caused by penetrating eye injuries. One child developed endophthalmitis following a fish hook injury to the eye and cultures from the anterior chamber of the enucleated eye grew both *A. hydrophila* and *P. shigelloides*[6]. Urinary isolates of *Aeromonas*, more commonly found in association with other organisms, have usually been recovered from patients with chronic genitourinary tract disorders such as hydronephrosis.

Extraintestinal human infections caused by *Aeromonas* and *Plesiomonas*

Pathogen	Type of infection
Aeromonas	Sepsis, meningitis, cellulitis, necrotizing fasciitis, ecthyma gangrenosum, pneumonia, peritonitis, conjunctivitis, corneal ulcer, endophthalmitis, osteomyelitis, suppurative arthritis, myositis, subphrenic abscess, liver abscess, cholecystitis and/or ascending cholangitis, urinary tract infection, endocarditis, ear, nose, and throat infections, septic abortion, balanitis, vaginal discharge
Plesiomonas	Sepsis, meningitis, cellulitis, suppurative arthritis, cholecystitis, endophthalmitis, pyometra

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0014-4754/87/040359-02$1.50 + 0.20/0

Antimicrobial susceptibilities of *Aeromonas* species and *Plesiomonas shigelloides*

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Key words. Aeromonas hydrophila; Aeromonas species; *Plesiomonas shigelloides;* antimicrobial susceptibilities.

Prior to 1980, antimicrobial susceptibilities of *Aeromonas* species and *Plesiomonas shigelloides* were determined primarily by disk diffusion testing. These organisms were typically susceptible to chloramphenicol, trimethoprim-sulfamethoxazole (TMP-SMZ), tetracycline, aminoglycosides and nalidixic acid, variably susceptible to erythromycin and polymyxins, and resistant to penicillin G, ampicillin, carbenicillin and cephalothin[7].

During the past six years, we have been testing the in vitro activities of antimicrobial agents against *Aeromonas hydrophila* with a standardized microdilution method using cation-supplemented Mueller-Hinton broth and an inoculum of 5×10^5 cfu/ml[11]. The minimal inhibitory concentrations (MICs) for 42 antimicrobial agents[3–6] are shown in table 1. Although aeromonads isolated from aquatic environments have shown significant fre-

Table 1. Susceptibilities of *Aeromonas hydrophila*

Antimicrobial agent	MICs (mg/l*) Range	MIC_{50}	MIC_{90}	Reference
Penicillin G	64– > 128	> 128	> 128	4
Ampicillin	16– > 128	> 128	> 128	4
Carbenicillin	8– > 128	> 128	> 128	4
Ticarcillin	8– > 128	> 128	> 128	4
Azlocillin	8– > 128	32	64	4
Mezlocillin	4– > 128	8	8	4
Piperacillin	1– > 128	4	8	4
Amoxicillin-clavulanate	4– > 16	> 16	> 16	6
Ticarcillin-clavulanate	1– > 64	16	> 64	6
Amdinocillin	0.25–4	1	2	4
Cephalothin	2– > 128	> 128	> 128	4
Cefazolin	4– > 128	128	> 128	4
Cefaclor	0.5– > 16	> 16	> 16	6
Cefamandole	0.25–32	2	8	4
Cefoxitin	0.5–128	8	32	4
Cefazaflur	0.5– > 128	64	> 128	4
Cefuroxime	0.25–8	1	4	4
Cefotaxime	≤ 0.06–4	≤ 0.06	0.25	4
Cefoperazone	≤ 0.13–8	0.5	2	3
Moxalactam	≤ 0.06	≤ 0.06	≤ 0.06	4
Aztreonam	≤ 0.016–0.13	≤ 0.016	0.03	5
Imipenem	0.06–1	0.5	0.5	5
Streptomycin	2– > 64	8	16	4
Kanamycin	0.5–8	2	8	4
Gentamicin	0.13–0.5	0.25	0.5	4
Tobramycin	0.13–2	1	2	4
Amikacin	0.5–4	2	4	4
Sisomicin	0.13–1	0.5	1	4
Netilmicin	0.13–1	0.5	1	4
Colistin	1– > 64	4	> 64	4
Tetracycline	0.5–2	1	2	4
Minocycline	0.5–4	1	4	4
Doxycycline	0.5–4	1	2	4
Chloramphenicol	0.5–8	1	4	4
Erythromycin	8–64	16	32	4
Clindamycin	≥ 64	> 64	> 64	4
Vancomycin	≥ 64	> 64	> 64	4
TMP-SMZ	2– > 64	4	8	6
Norfloxacin	≤ 0.016–0.13	≤ 0.016	0.03	5
Ciprofloxacin	≤ 0.04–0.016	≤ 0.004	0.008	5
Ofloxacin	≤ 0.03–0.13	≤ 0.03	0.06	6
Pefloxacin	≤ 0.03–0.13	≤ 0.03	0.06	6

* 20–25 strains for each drug. MIC_{50} and MIC_{90} are the MICs required to inhibit 50% and 90% of strains, respectively.

quencies of resistance to chloramphenicol, streptomycin and tetracycline[8], our studies have indicated that most strains are susceptible to new betalactams, aminoglycosides, chloramphenicol, tetracyclines, TMP-SMZ, and the fluoroquinolones.

All strains of *A. hydrophila* probably produce beta-lactamase[6] and beta-lactamase production correlates with relative resistance to the penicillins and cephalosporins but not to amdinocillin or moxalactam (table 1). These enzymes are inducible and are inhibited by clavulanic acid, but are only partially responsible for resistance to the beta-lactams[6, 9, 15]. Among the beta-lactam antibiotics, only amdinocillin, moxalactam, aztreonam, and imipenem have been active against all strains tested to date[2, 3–6].

Table 2. Correlation of β-lactamase production with MICs

β-Lactam	Typical MICs (mg/l) Weak* (N = 5)	Moderate (N = 3)	Strong (N = 2)
Ampicillin	> 128	> 128	> 128
Ticarcillin	64	> 128	> 128
Azlocillin	8	64	> 128
Mezlocillin	2	8	128
Piperacillin	1	8	128
Amdinocillin	1	1	2
Cephalothin	2	> 128	> 128
Cefamandole	0.5	4	32
Cefoperazone	0.1	0.2	8
Cefotaxime	≤ 0.1	≤ 0.1	4
Moxalactam	≤ 0.1	≤ 0.1	≤ 0.1

* Nitrocefin test (Cefinase; BBL Microbiology Systems, Cockeysville, Md).

There are probably at least three species which are included in the *A. hydrophila* complex: *A. hydrophila, A. sobria,* and *A. caviae.* Recent studies[10, 13] have indicated that in vitro susceptibilities of the three species are similar, although resistance to older penicillins and cephalosporins was more consistent with *A. hydrophila.*

The susceptibilities of *P. shigelloides* were also similar to those of *A. hydrophila*[1, 6, 7, 12–14] although some strains have been reported to be susceptible to ampicillin, carbenicillin, and cephalothin and less susceptible to gentamicin[1, 6, 12–14].

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