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Pasteurella multocida Infections

REPORT OF 34 CASES AND REVIEW OF THE LITERATURE

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Introduction

Pasteurella multocida, a small gram-negative coccobacillus, is part of the normal oral flora of many animals, including the cat and dog. *P. multocida* is a major pathogen in wound infections due to animal bites and can cause cellulitis, abscess, osteomyelitis, septic arthritis, or a variety of other infectious syndromes (Table 1). Over the years *P. multocida* has been the subject of a number of short general reviews (74, 80, 81, 86, 158). More recently, reviews have focused on selected aspects of *P. multocida* infection including meningitis (44), empyema (112), spontaneous bacterial peritonitis (160), bone and joint infections (56), and septicemia (111). A large series of cases with a comprehensive review, however, has not been published. We therefore report here 34 cases from the Massachusetts General Hospital and review the English literature.

Methods

Identification of Pasteurella multocida

Pasteurella multocida was identified by growth of a gram-negative rod with the following characteristics (30): growth on horse-blood agar medium without hemolysis; absence of growth on MacConkey's medium; positive reactions for catalase, oxidase, nitrate reduction, and indole production; negative reaction for urease; and patterns of sugar degradation consistent with *P. multocida.*

Selection of cases

The 17 cases in Table 2 represented all isolates of *P. multocida* identified by the Massachusetts General Hospital Bacteriology Laboratory in the 13-month period from September 1, 1980 to October 1, 1981 by means of a computer search. During the same period the laboratory processed 175,000 specimens of all types. The 17 cases in Table 3 were identified retrospectively by a questionnaire to members of the Infectious Disease Unit and represented only partial ascertainment for the period 1969 to 1982.

Antibiotic susceptibility testing

Routine susceptibility testing was performed by established techniques (125, 126) at 35°C using standardized antibiotic containing discs on Mueller-Hinton medium with and without 5% sheep blood. Results were similar for the two types of media.

Agar dilution susceptibility testing was performed on Mueller-Hinton agar plates without added blood, employing a Steers replicator. Bacteria were grown overnight at 37°C in dextrose phosphate broth and diluted in 0.9 percent NaCl to deliver 10^4 to 10^5 colony-forming units per spot. The plates were evaluated after incubation for 24 h at 37°C. Antibiotics were laboratory standard grade.

Minimum bactericidal concentrations were determined at 37°C by the macro-broth dilution technique (97), using Mueller-Hinton broth and subculturing onto Brucella agar supplemented with 5% horse blood.

Results and Discussion

History

The history of *P. multocida* has been summarized in several recent reviews (24, 74, 136). Bacteria of the genus Pasteurella were first observed in the blood of birds with fowl cholera in 1877. In 1880 Pasteur isolated the causative agent of fowl cholera, *P. multocida,* and characterized it morphologically and biochemically. In 1885 Kit isolated the organism from the blood of diseased cattle and named it *Bacterium bipolarmulticidium.* Hueppe in 1886 renamed the organism *Bacterium septicemia haemorrhagica;* he coined the term "hemorrhagic septicemia" to describe a disease caused by this organism and characterized by widespread visceral hemorrhages, occurring in lower animals. Ligieres in 1901 proposed a classification in which the species of Pasteurella would be named according to its host. Subsequent work by several laboratories established common biochemical and morphologic features among nonhemolytic members of the hemorrhagic septicemia group; isolates from all sources were grouped together as *Pasteurella septica* in 1929 and as *Pasteurella multocida* in 1939.

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TABLE 1. Spectrum of infections caused by *Pasteurella multocida*

*Skin (216)**
Cellulitis
Subcutaneous abscess
Infected decubitus or stasis ulcer
Bone and Joint (56)
Septic arthritis
Osteomyelitis
Septic arthritis with osteomyelitis
Bursitis
Oral and Respiratory Tract (61)
Tonsillitis or peritonsillar abscess
Sinusitis pharyngitis, epiglottitis
Otitis media and mastoiditis
Submandibular abscess
Tracheobronchitis
Pneumonia
Empyema
Cardiovascular System (59)
Bacteremia
Endocarditis
Mycotic aneurysm
Purulent pericarditis
Infected vascular graft
Central Nervous System (24)
Meningitis
Brain abscess
Subdural empyema
Gastrointestinal Tract (18)
Liver abscess
Spontaneous bacterial peritonitis
Omental or appendiceal abscess
Peritonitis due to ruptured viscus
Gastroenteritis
Genitourinary Tract (7)
Cystitis or pyelonephritis
Infected ileal loop
Renal abscess
Vaginitis, cervicitis
Bartholin gland abscess
Chorioamnionitis
Epididymitis
Eyes (5)
Conjunctivitis
Corneal ulcer
Endophthalmitis

* Number of cases reported in detail in the literature and in this series. Exact references can be found in the text.

The first case reported in a human, a farmer's wife with puerperal fever, was described in 1913 by Brugnatelli, who isolated a bacterium he felt to be *P. multocida* from the patient's blood (29). However, the organism would not currently be classified as *P. multocida*, as it was motile and bile resistant. *P. multocida* infection resulting from a cat bite was first described by Kapel and Holm in 1930 (89).

Bacteriology

P. multocida is a small, non-motile, non-sporeforming, gram-negative coccobacillus. On gram-stained smear the organisms generally appear as single bacilli but may occur in pairs or chains. They frequently show bipolar staining. The organisms are aerobic, facultatively anaerobic, and grow well at 37°C on blood, chocolate, and Mueller-Hinton agar, but not MacConkey's agar. Growth is facilitated by enriched media and increased carbon dioxide tension (24, 30). A selective medium has been developed to facilitate the isolation of *P. multocida* (92).

The genus Pasteurella is divided into four species: *P. multocida*, *P. ureae*, *P. hemolytica*, and *P. pneumotropica*. *P. multocida* is distinguished by lack of hemolysis on blood agar (greening without hemolysis may occur at 48 hours), negative urease and positive indole reactions, and pathogenicity in laboratory animals. The growth and biochemical characteristics of *P. multocida* involved in human infections have been the subject of a number of reports (48, 116, 117, 148, 161).

P. multocida contains a lipopolysaccharide endotoxin, but no exotoxin has been identified. Sixteen serotypes, six of which have been associated with human infections, have been characterized on the basis of heat stable 0 antigens (73). Multiple biotypes have been identified based on the ability of individual strains to ferment maltose, mannitol, xylose, sorbitol, trehalose, and arabinose (48, 73, 117, 148). Whether biotypes vary in pathogenicity for man is as yet unclear (161).

Antibiotic susceptibilities of clinical strains isolated at the Massachusetts General Hospital

We tested 19 strains of *P. multocida* isolated from human infections for antibiotic susceptibility *in vitro* (Table 4). The most active drugs were penicillin G and its derivatives (penicillin V, ampicillin, carbenicillin, ticarcillin, piperacillin, and mezlocillin), the second generation cephalosporins (cefoxitin and cefamandole), the third generation cephalosporins (cefoperazone, moxalactam, and cefotaxime), the tetracyclines (minocycline and tetracycline), and chloramphenicol. Less active drugs included the first generation cephalosporins (cephapirin, cephalothin, and cefazolin) and the semisynthetic penicillins (methicillin and nafcillin). Based on susceptibilities *in vitro*, an orally absorbed semisynthetic penicillin (dicloxacillin) and two orally absorbed cephalosporins (cephalexin and cefaclor) would not achieve blood levels sufficient to treat *P. multocida* infections reliably. Susceptibilities to the aminoglycosides were borderline and variable, indicating that these drugs should be used only after appropriate susceptibility testing. Our strains were not susceptible to concentrations of erythromycin that would be achieved after oral drug administration but were variably susceptible to levels that could be achieved by intravenous administration. *P. multocida* was resistant to vancomycin and clindamycin. Our agar dilution susceptibility data were

TABLE 2. All isolates of *P. multocida* at Massachusetts General Hospital: Sept. 1980–Oct. 1982

Case Number	Age Sex	Clinical Infection (site)	Animal Exposure	Culture Source	Associated Diseases	Treatment	Outcome
1	9 M	Cellulitis (Hand)	Dog bite	Wound	None	Erythromycin, topical silver sulfadiazine	Recovered
2	34 F	Cellulitis, Abscess (Hand)	Cat bite	Wound	None	Oral penicillin/cefazolin/cephalexin	Recovered
3	84 F	Cellulitis, Gangrene (Leg)	Cat bite	Wound	Vascular disease	Clindamycin/gentamicin/cefoxitin/tobramycin, amputation	Died
4	4 M	Cellulitis (Leg)	Cat bite and scratch	Wound	Cerebral palsy	Oral penicillin	Recovered
5	52 F	Cellulitis (Hand)	Dog bite	Wound	Rheumatoid arthritis, SLE	Cephalexin/cephazolin/cefoxitin	Recovered
6	42 F	Cellulitis (Hand)	Cat bite	Wound	None	Penicillin	Recovered
7	67 M	Cellulitis (Finger)	Dog bite	Wound	Diabetes	Penicillin/cephalexin	Residual stiffness
8	38 M	Cellulitis (Finger)	Cat bite	Wound	Not recorded	Oxacillin	Recovered
9	19 M	Cellulitis (Thumb)	Cat bite	Wound	None	Ampicillin/penicillin	Recovered
10	74 F	Cellulitis, Osteomyelitis, Abscess (Leg)	Cat bite	Wound, abscess	Diabetes	Cefazolin/chloramphenicol/cephalothin/penicillin	Slow healing
11	39 M	Septic arthritis, Osteomyelitis (Finger)	Cat bite	Wound, joint	Poor dentition	Drainage, cephapirin/TMP-SMX/gentamicin/penicillin	Stiff joint
12	39 M	Decubitus ulcer	Not recorded	Wound	Paraplegia	Cefazolin, debridement/graft/femoral head resection	Slow healing
13	33 M	Chronic ulcer, Osteomyelitis (Foot)	Not recorded	Wound	Paraplegia	Cefazolin/cephalothin/ampicillin, below knee amputation	Recovered
14	64 M	Chronic ulcer, Osteomyelitis (Second toe)	Not recorded	Wound	Alcohol abuse	Cefazolin, amputation of second toe	Recovered
15	71 F	Tracheobronchitis	Not recorded	Sputum	COPD, CAD	Ampicillin	Recovered
16	78 F	Colonization (Tracheobronchial tree)	None	Sputum	COPD, CHF	Chest physical therapy	Recovered
17	69 F	Pneumonia	Not recorded	Sputum, Bronchial washings	COPD, s/p lobectomy for lung cancer	Cefazolin/tobramycin/cephalexin, bronchodilators	Recovered

COPD-chronic obstructive pulmonary disease, CAD-coronary artery disease, CHF-congestive heart failure, TMP-SMX-trimethoprim-sulfamethoxazole, SLE-systemic lupus erythematosus.

TABLE 3. Selected cases of *P. multocida* infections at Massachusetts General Hospital: 1969–1980

Case Number	Age Sex	Clinical Infection (site)	Animal Exposure	Culture Source	Associated Diseases	Treatment	Outcome
18	23 M	Cellulitis (Arm)	Cat bite	Wound	None	Oral penicillin	Unknown
19	56 F	Cellulitis (Leg)	Cat bite or scratch	Wound	None	Penicillin	Recovered
20	60 F	Cellulitis (Hand)	Dog bite	Wound	None	Clindamycin	Recovered
21	58 F	Cellulitis (Leg)	Cat scratch	Wound	Rheumatoid arthritis	Penicillin/gentamicin	Recovered
22	9 F	Cellulitis (Face)	Cat scratch	Wound	None	Penicillin/oxacillin/ cephalexin	Recovered
23	65 M	Cellulitis, Abscess (Hand)	Cat scratch	Wound	Alcohol abuse	Drainage, cefazolin/ cephalothin	Recovered
24	24 M	Cellulitis, Abscess (Hand), Tenosynovitis	Dog bite	Wound	None	Drainage, clindamycin/ cephalexin/gentamicin/ cephalothin	Recovered
25	17 F	Cellulitis (Face)	Cat bite	Wound	None	Cloxacillin	Recovered
26	24 F	Cellulitis (Hand)	Cat bite and scratch	Wound	None	Erythromycin/chloram-phenicol/cefazolin	Recovered
27	52 M	Cellulitis, Septic arthritis, Osteomyelitis (Finger)	Cat bite	Wound, joint	Alcohol abuse	Penicillin	Unknown
28	51 F	Osteomyelitis (Finger)	Cat bite	Bone	None	Oxacillin/gentamicin/ cephalothin/penicillin/ tetracycline	Nonunion of pathologic fracture
29	85 M	Cellulitis, Septic arthritis, Osteomyelitis (Finger)	Dog bite	Wound	None	Clindamycin/cephalothin/ chloramphenicol/tetra-cycline	Decreased range of motion
30	10 M	Endophthalmitis	Cat scratch	Vitreous	None	Ampicillin/gentamicin/ cephalothin/oxacillin, vitrectomy, antibiotic eye drops, subconjuncti-val gentamicin	Recovered, Corrected Vi-sion 20/30
31	2 mo F	Meningitis	Cats	CSF, blood	None	Ampicillin/chloramphenicol	Recovered
32	11 F	Colonization (Ileal loop)	Not recorded	Ileal loop	Thalassemia	None	No clinical infection
33	68 F	Stasis ulcer (Leg)	Not recorded	Skin	Chronic edema	Local wound care, diuretics	Recovered
34	62 F	Pneumonia	Not recorded	Bronchial washings	Hypertension	Erythromycin/cephalexin	Recovered

TABLE 4. Antibiotic susceptibility of 19 human isolates of *P. multocida*

Antibiotic	Kirby-Bauer Disc Susceptibility			Agar Dilution Susceptibility	
	Disc potency (μg/disc)	Zone of Inhibition (mm)* Median (range)	Percent Susceptible (Percent intermediate)	MIC_{50} (μg/ml)†	MIC_{90} (μg/ml)†
Penicillin G	10	28 (27-31)	100	0.125	0.125
Penicillin VK				0.25	0.5‡
Ampicillin	10	27 (25-29)	100	0.25	0.25
Carbenicillin	100	30 (28-35)	100		
Ticarcillin				0.5	0.5
Mezlocillin	75	31 (28-35)	100	0.06	0.125
Piperacillin	100	33 (28-36)	100		
Methicillin	5	19 (18-20)	100		
Nafcillin				4.0	4.0
Dicloxacillin				8.0	16.0
Cephalothin	30	27 (22-30)	100	2.0	4.0
Cephapirin				0.5	2.0
Cefazolin				1.0	2.0
Cephalexin				4.0	16.0
Cefoxitin	30	25 (21-27)	100	1.0	2.0‡
Cefamandole	30	29 (24-32)	100	0.125	1.0
Cefaclor				4.0	32.0
Moxalactam	30	27 (25-30)	100	0.25	0.25
Cefotaxime	30	30 (28-33)	100	0.06	0.06
Cefaperazone	30	31 (27-34)	100		
Vancomycin	30	7 (6-11)	0 (5)		
Erythromycin	15	16 (14-18)	32 (68)	4.0	8.0
Chloramphenicol	30	29 (28-32)	100	0.25	0.5
Tetracycline	30	27 (24-28)	100	0.25	0.5
Minocycline				0.25	0.25
Rifampin				0.5	1.0
Clindamycin	2	6 (6)	0	16.0	32.0
Trimethoprim-Sulfamethoxazole				0.5§	1.0§
Sulfadiazine				4.0	128.0
Streptomycin	10	8 (6-17)	5 (20)	32.0	32.0
Gentamicin	10	13 (12-18)	5 (74)	2.0	2.0‡
Tobramycin	10	13 (10-17)	5 (79)	4.0	4.0
Amikacin	30	23 (12-18)	5 (26)	32.0	32.0

* Disc diameter is 6 mm.

† MIC_{50} and MIC_{90} represent the lowest concentration of drug that inhibits the growth of at least 50 percent and 90 percent of strains tested, respectively.

‡ 15 strains were tested.

§ The drug concentration is for the sulfamethoxazole component.

consistent with previously published reports (48, 137, 150, 153).

We have also determined minimum inhibitory concentrations (MIC) and minimum bactericidal concentrations (MBC) for four of our isolates using the macro-tube broth dilution technique. Our data showed that penicillin G and moxalactam were bacteriostatic and bactericidal at the same concentrations. For tetracycline the MBC was 2-fold to 32-fold greater than the MIC (highest MBC = 16 μg/ml), and for chloramphenicol the MBC level was 8-fold to 32-fold greater than the MIC (highest MBC = 16 μg/ml). Trimethoprim-sulfamethoxazole, inhibitory at 0.5 μg sulfamethoxazole per ml, was not bactericidal at 128 μg of sulfamethoxazole per ml. Our data are consistent with those of Stevens et al (153) except for chloramphenicol, for which we found a larger difference between the MIC and MBC. This discrepancy is likely due to their use of a smaller inoculum in the mini-broth technique and their use of Mueller-Hinton agar rather than blood agar; the latter has a higher efficiency of plating, for determining colony counts in the MBC assay (D. J. Weber and J. S. Wolfson, unpublished observations).

Epidemiology

Pasteurella multocida has been isolated from the digestive system or respiratory tract of domestic cats and dogs, rats, mice, rabbits, cattle, sheep, swine, reindeer, horses, monkeys, buffaloes, lions,

panthers, and lynx (22, 38, 86, 121, 136, 140). Carriage rates of *P. multocida* in the oral or nasal secretions of a variety of apparently well animals are quite high: 70 to 90% in cats (121, 147), 50 to 66% in dogs (8, 138), 51% in pigs (147), 14% in Norway rats (140), and 3.5% in buffaloes (147). *P. multocida* is pathogenic in many species of animals and is capable of causing serious epizootic infections. The organism is the agent of hemorrhagic septicemia of cattle, commonly known as "shipping fever," in which *P. multocida* is a secondary invader following myxovirus infection. The organism also causes pneumonia in goats and sheep, avian cholera in waterfowl, and upper respiratory infections (snuffles) in rabbits (38, 39, 136).

Clinical infections in humans most often follow cat bites, cat scratches, or dog bites (55, 80, 163, 164). However, infection has followed the bites of a variety of other animals including the opossum (80, 163), rat (80), lion (28, 80, 164), rabbit (22), pig (27), and wolf (27), and has been associated with cleaning turkeys (85) or being kicked by a horse (113). Occasionally *P. multocida* has been found as a commensal in the sputum of otherwise well patients without underlying chronic pulmonary or sinus disease. Jones et al (86) were able to isolate the organism from pharyngeal cultures of 2 of 100 animal handlers but not from 75 unselected patients (42 with animal exposure) seen in an office practice. Smith (148) isolated *P. multocida* from the pharynx of 2 of 71 healthy veterinary students.

Pasteurella multocida can remain viable in water for 7 to 25 days and in soil for up to 21 days but is killed by exposure to direct sunlight for 10 minutes (119). In carcasses of fowl the organism can persist for up to 60 days (119). Most human infections result from direct inoculation via bites. Infections following animal exposure in the absence of bites or scratches probably stem from contact with secretions of the animal. A nosocomial outbreak of *P. multocida* infections has been described, but the mode of transmission was not defined (82). Human-to-human spread of infection has not been documented, nor has contaminated food or water been implicated as a source of infection. Infection with this organism occurs worldwide. Seasonal clustering has not been observed (58, 80).

Soft-tissue infections following animal bites or scratches

General features: Animal bites are a major public health problem. An estimated 500,000 to 1 million animal bites occur each year (34, 139) and account for 1% of all emergency room visits in the United States (33). Although most bites produce minor injury, at least 10% require suturing, and 1–2% require hospitalization (16). The infection rate from penetrating dog bites has been reported to be as low as 2% (68) and as high as 29% (95), but is generally reported in the range of 5–15% (2, 35, 51). Dog bites account for 75 to 91% of animal bites; cat bites account for 5–15% but are more likely to become infected (51, 139).

Retrospective studies have identified *P. multocida* as a major pathogen in infections resulting from animal bites. In small prospective studies, *P. multocida* has been isolated from 0 to 26% of dog-bite wounds (21, 36, 65). Larger studies are needed to determine the true incidence of *P. multocida* in uninfected and infected wounds inflicted by animals.

Local wound infections from animal bites are the most common human infections caused by *P. multocida* (27, 67, 80). Our 23 patients (Table 2, cases 1–11 and Table 3, cases 18–29) were typical of series (of ≥5 cases) previously reported in epidemiology and clinical features (4, 5, 58, 72, 76, 77, 80, 86, 99, 101, 163, 164, 166). In our series, cat bites or scratches were responsible for infection in 17 patients and dog bites in 6 patients. The upper extremity was involved in 16 infections, the lower extremity in 5, and the face in 2. Seven patients (30%) had underlying diseases that may have been predisposing factors; these included diabetes mellitus (two cases), alcohol abuse (two cases), rheumatoid arthritis (one case), rheumatoid arthritis and systemic lupus erythematosus (one case), and severe vascular disease (one case).

P. multocida wound infections were characterized by a rapidly developing and intense inflammatory response. Ten patients (43%) developed symptoms within 24 hours of having been bitten or scratched and another 4 (17%) within 48 hours. Presenting manifestations included local erythema, warmth, swelling, and tenderness in 20 patients (87%). Pain and swelling were prominent. Purulent drainage was present in nine patients (39%). Most patients were afebrile when initially seen by a physician, but four patients (17%) had temperatures ranging between 37.8°C and 38.9°C. Lymphangitis was noted in four patients (17%), and regional adenopathy was present in two (9%).

In our 23 cases of local cutaneous infection, treatment consisted of wound care, elevation of the involved extremity, and administration of antibiotics. Twelve patients received oral antibiotics within 48 hours of sustaining their bite or scratch. Of these patients, eight (four receiving penicillin or ampicillin, three receiving erythromycin, and one receiving cephalexin) later required hospitalization. All hospitalized patients, with one exception, received intravenous antibiotics which included either a penicillin or a cephalosporin. Patients defervesced rap-

idly after institution of intravenous antibiotics: 74% of patients became afebrile within 48 hours, and only one patient remained febrile beyond 4 days. Patients without complications were hospitalized for an average of 7 days (range, 2–16 days).

Of our 23 patients, 9 (39%) suffered a complication of the animal bite or initial cellulitis. Complications included septic arthritis with osteomyelitis, osteomyelitis, abscesses requiring surgical drainage, and tenosynovitis. One patient died from cardiopulmonary failure after developing gangrene of her leg and undergoing an amputation; necropsy revealed no evidence of *P. multocida* infection. In the literature, tendon sheath involvement and abscess formation were the most common reported complications of *P. multocida* wound infections (4, 58, 72, 77, 99, 163). Rare complications included bacteremia (58, 77, 115, 170) or superimposed clostridial infection (142).

M.G.H. Case 22—Cellulitis following cat scratch: R.D., a 9-year-old girl, was admitted to our hospital with facial erythema and fever 12 hours after having been scratched on the cheek by a cat.

On physical examination, the patient's axillary temperature was 38.2°C. On her cheek there were two parallel scratches with surrounding warmth, erythema, and edema. Admission cultures of the wound revealed a moderate number of *P. multocida* and very rare non-enteric gram-negative rods and alpha streptococci. The peripheral leukocyte count was 21,300/mm^3 (83% polymorphonuclear cells).

The patient was treated with warm soaks to the wound and intravenous oxacillin (4 g/d) for 6 days, followed by intravenous penicillin G (2 million U/d) for 4 days. She defervesced within 24 hours of initiation of therapy and was discharged fully recovered after 10 days of intravenous therapy. An additional five-day course of cephalexin was prescribed at time of discharge.

M.G.H. Case 24—Cellulitis and abscess following a dog bite: D.D., a 24-year-old man with a history of penicillin allergy, was admitted for extensive cellulitis 2 days after having been bitten by a dog. While interrupting a dog fight, the patient suffered multiple wounds to his left palm and base of his left thumb. He was seen in the emergency room of another hospital where under local anesthesia the wound was explored and irrigated, a digital nerve repaired, and all lacerations sutured. On discharge the patient was treated with oral erythromycin. Within 24 hours he became febrile and was admitted 2 days later to the Massachusetts General Hospital because of increased swelling and pain in his hand.

On physical examination, the patient was afebrile. The three sutured lacerations on his palm were surrounded by erythema and edema which extended to his mid-forearm. The laceration on the thenar area was draining pus. All joints had a normal range of motion, but flexion or extension of the left third finger produced pain.

On the day of admission, all sutures were removed, and a collection of pus was found beneath the thenar wound. Culture of this material grew abundant *P. multocida* and moderate *E. coli* on the primary plates, and group G streptococci, alpha hemolytic streptococci, *Enterobacter aerogenes*, and *Bacteroides melaninogenicus* in the thioglycolate broth. The leukocyte count was 16,800/mm^3 (86% polymorphonuclear cells).

Initial treatment consisted of removal of sutures, splinting, and intravenous clindamycin (1.8 g/d) and gentamicin (180 mg/d). Four days after admission the area was explored, and tendon sheath involvement was found. Copious irrigation was performed, and a drain was placed. Antibiotic treatment was changed to intravenous cephalothin (9 g/d). Over the next 5 days, the patient markedly improved and was discharged on a regimen of oral cephalexin (500 mg, 4 times/d). Information regarding long term follow-up was not available.

Comment: These two cases demonstrate the rapidity with which *P. multocida* can cause cellulitis and even frank abscess formation following not only an animal bite but also a cat scratch. They also illustrate the need for continued observation of all animal-bite wounds, the possibility of tendon sheath involvement, and the potential presence of multiple pathogens. Local wound care and high doses of appropriate intravenous antibiotics usually result in resolution of the cellulitis in 5 to 10 days. Surgical intervention is necessary for drainage of abscesses. Both of the above patients received cephalexin, an inappropriate choice because oral cephalosporins do not achieve blood levels high enough to treat *P. multocida* infections reliably. The preferred oral treatment of *P. multocida* infections is either penicillin VK or, in the patient with a prior reaction to penicillin, tetracycline.

Soft tissue infections not associated with animal bites or scratches

Occasionally *P. multocida* has been found as part of the mixed flora of decubitus or stasis ulcers (27, 67, 76, 81). Our series included four such instances (cases 12, 13, 14, 33). Other types of local infections due to this organism included paronychias (81) and wound infections following abdominal (81), orthopedic (20), or gynecologic (81) surgery.

Bone and joint infections

The most frequent serious infections caused by *P. multocida* were septic arthritis (6, 10, 56, 66, 69, 85, 86, 103, 108, 114, 127, 129, 134, 149, 163, 171), osteomyelitis (3, 4, 25, 32, 33, 47, 56, 76, 84, 86, 99, 101, 106, 124, 158, present report: cases 10, 13, 14, 28), or septic arthritis with osteomyelitis (4, 15, 31, 45, 77, 89, 101, 127, 167, present report: cases 11, 27, 29). Each had a distinctive clinical pattern (Table 5). A single case of an infected suprapatellar bursa with bacteremia has been reported (61).

Septic arthritis: Septic arthritis without osteomyelitis most commonly affected a single joint (88%), usually the knee (76%) (Table 5). There was a predilection for involvement of a joint previously

TABLE 5. Bone and joint infections (summary of reported cases including current series)

Age	Sex	Affected Area	Animal Exposure	Other Diseases	Outcome
Septic Arthritis (17 patients)					
0–20: 2	Male: 4	Knee (native): 8	Cat bite: 5	Rheumatoid arthritis and corticosteroid Rx: 6	Full recovery: 10
21–40: 1	Female: 13	Knee (prosthesis): 5	Cat scratch: 4	Degenerative arthritis: 3	Bone or joint damage: 3
41–60: 6		Knee and shoulder: 1	Cat and dog: 2	Rheumatoid arthritis: 2	Death: 2
>60: 8		Shoulder: 1	Cat: 1	Alcoholism, hepatitis: 2	Slow healing: 1
		Elbow and PIP: 1	Dog bite: 1	History of periarthritis: 1	NR: 1
		MCP: 1	Dog: 1	Pregnancy: 1	
			Cattle: 1	None or NR: 2	
			NR: 2		
Osteomyelitis (24 patients)					
0–20: 4	Male: 9	Finger or toe: 9	Cat bite: 8	Fractures: 3	Full recovery: 11
21–40: 2	Female: 14	Radius or ulna: 4	Dog bite: 8	Diabetes mellitus: 3	Amputation: 4
41–60: 6	NR: 1	Tibia or fibula: 4	Cat bite (remote): 1	Cirrhosis, alcoholism: 1	Slow healing: 4
>60: 11		Hand or wrist: 4	Cat and dog: 1	Chronic edema: 1	Deformity: 3
NR: 1		Spine: 2	None or NR: 6	Alcoholism, surgery: 1	Nonunion: 1
		Foot: 1		None or NR: 15	Continued pain: 1
Septic Arthritis with Osteomyelitis (12 patients)					
0–20: 1	Male: 7	Finger and IP: 8	Cat bite: 9	Diabetes mellitus: 2	Abnormal joint: 7
21–40: 3	Female: 5	Wrist and MPC: 2	Dog bite: 2	Rheumatoid arthritis: 1	Amputation: 2
41–60: 7		Wrist and navicular: 1	None: 1	Fracture: 1	Full recovery: 1
>60: 1		Wrist and metacarpal: 1		Alcoholism: 1	Bone necrosis: 1
				None or NR: 7	NR: 1

NR-not recorded, PIP-proximal interphalangeal, IP-interphalangeal, MCP-metacarpophalangeal.

damaged either by rheumatoid arthritis (47%) or degenerative joint disease (18%), or for involvement of prosthetic joints (29%). In most cases the arthritis had been of long duration. Patients with altered systemic host defenses were also at increased risk: 35% of patients with septic arthritis were receiving corticosteroids, and 12% had alcoholic liver disease. Most cases involved cat or dog bites distal to the affected joint without direct penetrating injury to the joint itself (59%). In 29% of patients, infection occurred without a history of bites or scratches but with exposure to animals. In the remaining 12% of cases a history of animal exposure was not recorded.

Manifestations of joint involvement were typical of those of septic arthritis and included swelling, tenderness, warmth, and erythema. Joint aspiration revealed a purulent fluid with a leukocyte count of 50,000 to 290,000/mm^3 with a polymorphonuclear cell predominance, low glucose, and elevated protein levels. Gram-stained smear revealed the organism in 45% of the cases in which results were recorded.

Successful treatment can be achieved by employing the standard therapy for treating septic joints: high doses of parenteral antibiotics and multiple aspirations of the joint. Open drainage does not appear to be either necessary or desirable. Prosthetic joint infection has been treated successfully with antibiotics and open drainage (6, 149), antibiotics and repeated aspirations (103), or antibiotics alone (69), but may require debridement and removal of the prosthesis (66).

Infections with more than one organism have been reported in two cases. In one case *P. multocida* and *Staphylococcus aureus* were isolated from a prosthetic joint (156). Removal of the prosthesis and joint fusion were required to eradicate the infection. In the other case *P. multocida* and *Streptococcus sanguis* were isolated by open synovial biopsy from a patient with sternoclavicular arthritis (114). Treatment consisted of debridement and intravenous penicillin.

Osteomyelitis, general features: Osteomyelitis resulted from either local extension of soft tissue infection or direct inoculation of *P. multocida* into periosteum by the cat or dog bite. Osteomyelitis was commonly preceded by significant wound infection and cellulitis, in contrast to septic arthritis where no bite or scratch was noted in 29% of cases. Cat bites more commonly preceded bone infection, presumably because the small, sharp teeth of cats may easily penetrate the periosteum. Dog-bite wounds leading to osteomyelitis tended to be extensive. Conditions associated with osteomyelitis have included fractures (4, 76, 84), surgery (56), cirrhosis (32), and diabetes mellitus (86, 99).

P. multocida osteomyelitis may involve any bone but most commonly occurred in the bones of the fingers, hand, wrist, forearm, or leg (Table 5). Acute osteomyelitis became radiographically apparent in most cases within 2 to 10 weeks of the injury (4, 5, 25, 33, 84, 99, 101, 106, 158). Chronic osteomyelitis, with formation of sequestra, has developed (47, 56).

Successful treatment has been reported with the use of antibiotics alone (56, 99, 101, 158), debridement alone (3, 4), or antibiotics and debridement (25, 32, 33, 47, 56, 84, 99, 106). Complications occurred in 54% of patients reported with *P. multocida* osteomyelitis and included slow healing, nonunion, joint fusion, limitation of motion, and residual deformity.

M.G.H. Case 28—Osteomyelitis: C.H., a 51-year-old woman, suffered multiple cat bites to her right hand. She was seen in an emergency room where her wounds were cleaned and sutured. Two days later she returned to the emergency room with swelling and erythema of her thumb. She was treated for one week with oral penicillin with resolution of symptoms. One week later symptoms recurred, and she received an additional week of therapy with oral penicillin. At the conclusion of this period of treatment she was admitted to the Massachusetts General Hospital with swelling, erythema, and tenderness of her right thumb.

On physical examination, her temperature was 37.1°C. The right thumb distal to the inter-phalangeal joint was markedly swollen, tender, and warm, but there was good range of motion of the joint. There was no regional lymphadenopathy.

On the day following admission, the patient underwent a drainage procedure, which revealed the distal phalanx of the thumb to contain loculated pus and to have a pathologic fracture. The patient was treated initially with intravenous oxacillin (8 g/d) and gentamicin (180 mg/d). On the fifth day of treatment, when cultures of the loculated pus revealed *P. multocida*, antibiotic therapy was changed to intravenous penicillin (10 million U/d). After 14 days of parenteral therapy, because the patient wanted to return home, an oral regimen of penicillin and probenecid was begun. Because the titer of serum bactericidal activity was less than 1:2 against the patient's *P. multocida*, treatment with intravenous penicillin was reinstituted. When a rash consistent with a penicillin drug eruption developed, the antibiotic treatment was changed to cephalothin and then, with persistence of the rash, to tetracycline. The patient was discharged after 37 days on treatment with oral tetracycline. Follow-up revealed persistence of nonunion.

Comment: As illustrated in this case report, osteomyelitis due to *P. multocida* is frequently not diagnosed until weeks after an injury, after apparently adequate treatment of an initial cellulitis. Careful follow-up of extensive bites or deep puncture wounds from cat teeth is mandatory for early diagnosis of osteomyelitis. Prolonged antibiotic treatment is necessary to eradicate the infection, but there is a moderate likelihood of residual skeletal abnormality.

Septic arthritis with osteomyelitis, general features: The combination of septic arthritis with osteomyelitis occurred in a defined setting (Table 5). Almost all cases involved cat bites of the hand resulting in osteomyelitis of the phalanx and interphalangeal arthritis. Regardless of the mode of therapy, functional outcome in 10 of 12 cases reported in the literature was poor, with decreased joint mobility, ankylosis, bone necrosis, or amputation.

M.G.H. Case 11—Septic arthritis with osteomyelitis: W.F., a 39-year-old man, was admitted to the Massachusetts General Hospital with swelling, tenderness, and purulent drainage from his right index finger 9 days after having been bitten by a cat. The patient described sucking on the wound "like it was snakebite" in an effort to clean it out.

On physical examination, the patient's temperature was 37.3°C. His right index finger was markedly swollen, especially over the metacarpophalangeal joint. Lymphangitis extended to the midforearm, and small axillary nodes were present. The leukocyte count was 10,300/mm^3. X-ray examination revealed soft tissue swelling in the region of the second metacarpophalangeal joint without evidence of destruction of bone. Wound cultures grew abundant *P. multocida*, *Staphylococcus epidermidis*, *Bacteroides melaninogenicus*, and *Bacteroides species*. Aspiration of the joint yielded only abundant *P. multocida* on culture.

The patient was treated with drainage procedures of the finger and joint on the first, third, and eighth days of hospitalization. Initial antibiotic treatment consisted of intravenous gentamicin (300 mg/d) and cephapirin (6 g/d). On the ninth hospital day antibiotics were changed to oral trimethoprim-sulfamethoxazole for two days, followed by intravenous penicillin (12 million U/d) for 14 days. Radiologic evaluation 21 days after admission revealed erosions of the head of the second metacarpal and base of the second proximal phalanx consistent with osteomyelitis. On discharge the patient was treated with a course of oral penicillin. Follow-up revealed the patient doing well with a slightly stiff joint.

Comment: This case of combined *P. multocida* septic arthritis and osteomyelitis is typical of reports in the literature: the patient suffered a cat bite involving a finger joint and phalanx and did not recover full use of his finger.

Oral and respiratory tract infections

Spectrum of infections: The respiratory tract was second only to animal-bite wounds as a source of *P. multocida* isolates from humans (27, 67, 81). The bacterium has been isolated as the etiologic agent in bronchitis (54, 59, 76, 81, 110, 118, present report: case 15), pneumonia (17, 23, 37, 54, 59, 76, 79, 85, 86, 107, 112, 118, 120, 135, present report: cases 17 and 34), empyema (7, 28, 54, 64, 76, 77, 79, 85, 112, 118, 120, 141, 162), sinusitis (11, 86, 118), otitis media (27, 76), and tonsillitis (81). Abscess formation has been reported in the frontal sinus (118), peri-tonsillar space (118), submandibular space (148, 161), brain (complicating otitis media and mastoiditis) (71, 94, 157, 169), and lung (102, 135, 141).

Bronchitis, general features: P. multocida is capable of colonizing or, less commonly, invading the bronchial tree in patients with underlying respiratory tract disease. Bronchiectasis was the most common predisposing condition (18, 40, 47, 78, 81, 109, 118). Other conditions included carcinoma of the lung, chronic obstructive pulmonary disease, emphysema, chronic sinusitis, and chronic bronchitis (17, 54, 78, 81, 82, 86). In patients with chronic rhinosinusitis or bronchiectasis, *P. multocida* has existed as a saprophyte for 5 months to 14 years (11, 17, 19, 40, 109, 112).

M.G.H. Case 15—Tracheobronchitis: T.C., a 71-year-old white woman with a two-year history of stable angina and dyspnea on exertion, was admitted to the Massachusetts General Hospital after three hours of severe substernal chest pain. She also related a history of coryza, cough productive of thick yellow sputum, hoarseness, and sweats for one week. She denied fever or pleuritic chest pain. A history of exposure to animals was not sought.

Physical examination revealed a temperature of 37.2°C, a blood pressure of 170/100 mm Hg, a pulse rate of 80/min, and a respiratory rate of 24/min. The chest had an increased diameter but was clear on auscultation.

On laboratory examination, the leukocyte count was 9,200/mm^3 with a normal differential count. Chest radiographs showed atelectasis at the right base and over-inflation consistent with chronic obstructive pulmonary disease and were unchanged from previous studies. Gram-stained smear of sputum revealed numerous polymorphonuclear cells and gram-negative coccobacilli.

A myocardial infarction was excluded. She was felt to have tracheobronchitis and was treated with chest physical therapy and ampicillin, intravenously for 2 days and then orally for 9 days. Sputum cultures grew abundant *P. multocida*. The patient's respiratory tract symptoms cleared completely with therapy. Pulmonary function tests after the resolution of tracheobronchitis confirmed the presence of chronic obstructive pulmonary disease.

Comment: This case illustrates the ability of *P. multocida* to cause respiratory tract infection, its predilection for patients with underlying chronic pulmonary disease, and the response of infection to antibiotics and chest physical therapy. In general, patients with mild respiratory tract infections respond well to treatment with oral ampicillin or tetracycline.

Pneumonia, general features: Twenty-five well-documented cases of *P. multocida* pneumonia have been reported. Patients ranged in age from 46 to 88 years (median age, 69). The majority of patients had underlying pulmonary disease including bronchitis or chronic productive cough (five cases), bronchiectasis (three cases), pulmonary fibrosis (one case), carcinoma of the lung (one case), lymphoma involving the lung (one case), or unspecified chronic pulmonary disease (seven cases). Present-

ing symptoms were variable and included productive cough (eight cases), shortness of breath (seven cases), and fever with chills (four cases). Other symptoms were common and included sweats, malaise, abdominal pain, and anorexia. On presentation, 9 of 14 patients had a temperature greater than 37.7°C. Chest examination often revealed localized findings (dullness, rhonchi, wheezes) consistent with pneumonia. Peripheral leukocyte counts were greater than 11,000/mm^3 in 6 of 12 patients (maximum count, 44,200/mm^3). Pulmonary involvement by chest x-ray was lobar (10 cases), multilobar (5 cases), or patchy and diffuse (4 cases). Multilobar infections were usually bibasilar. Only three cases involved the upper lobes. Pleural effusions or empyema were present in five patients.

In 15 patients *P. multocida* was isolated from the sputum. The diagnosis was confirmed in the other patients by culture of material obtained by transtracheal aspiration (three cases), by thoracentesis (two cases), by blood culture (two cases), or by bronchoscopy (two cases), or at postmortem examination (one case). Complications of pneumonia included bacteremia (seven cases), empyema (six cases), abscess formation (two cases), and meningitis (one case). Nine patients (36%) died, five of respiratory failure from 3 to 6 weeks after initiation of treatment. The extent of underlying pulmonary disease likely contributed to this high mortality.

M.G.H. Case 17—Diffuse pneumonia: C.S., a 69-year-old white woman, entered the hospital with a six-week history of low-grade fever, shortness of breath, fatigue, cough, and anorexia. The patient's past medical history was remarkable for a right lower lobectomy for squamous cell carcinoma of the lung, a Commando procedure for oral carcinoma, and a hysterectomy for cervical carcinoma. Each tumor was considered to be an independent malignancy. There was a history of chronic obstructive pulmonary disease. A history of animal exposure was not sought.

On physical examination the patient's temperature was 37.2°C. Chest examination revealed rhonchi, dullness, and rales at the right base. Laboratory studies showed a peripheral leukocyte count of 10,300/mm^3 with a normal differential count. Chest radiographs revealed chronic obstructive pulmonary disease and patchy bilateral bronchopneumonia. Bronchoscopy showed no endobronchial lesions. Bronchial washings and biopsies revealed no evidence of recurrent tumor. Gram-stained smears of sputum showed abundant gram-negative diplococci and bacilli. *P. multocida* was isolated from sputum and bronchial washings. The patient was treated with intravenous cephalothin and tobramycin for one day, and then intravenous cefoxitin for 12 days with symptomatic improvement. Infiltrates seen on chest radiographs gradually cleared.

Comment: This case again illustrates the predilection of *P. multocida* to infect a host with impaired local defenses. Although *P. multocida* pneumonia usually involves a single lobe and has a short prodrome, this case shows that there may be an insidious presentation and diffuse parenchymal involvement.

Empyema: Empyema has been reported in 15 cases. Excluding one pediatric patient (age 8), the average age of the 12 patients for whom information was available was 71 years. Animal exposure was noted in seven cases. Underlying pulmonary disease was present in 12 patients and included bronchitis or chronic cough (5 cases), bronchiectasis (4 cases), bronchial obstruction (2 cases), and pulmonary lymphangiectasia (1 case). Other underlying conditions included cirrhosis (two cases) and congestive heart failure (two cases). All but one case presented with respiratory tract symptoms, including dyspnea, cough, pleuritic pain, and hemoptysis. Fever, weakness, fatigue, and anorexia were common. The duration of symptoms prior to presentation ranged from 2 days to 5 weeks. The leukocyte count was elevated in seven of eight cases, ranging from 13,400 to 19,800/mm^3. An associated pneumonia was reported in six cases (40%). Thoracentesis was performed in 10 cases, and *P. multocida* was isolated from the pleural fluid in each. Organisms were seen on gram-stained smear in three cases. The fluid characteristics, described in seven patients, were reported as purulent in all and bloody in four. In the 10 patients whose diagnosis was made by thoracentesis, *P. multocida* was also recovered from the sputum in 3, blood and joint fluid in 1, and urine in 1. In the remaining five cases of empyema, the means of diagnosis was by necropsy in one and was unspecified in four.

Treatment consisted of repeated thoracentesis or closed-tube drainage in eight cases, with seven patients also receiving systemic antibiotics; pneumonectomy in two; and antibiotic therapy alone in three. Treatment of the other two cases was not recorded. A broncho-pleural fistula developed in 3 patients, and 6 of the 11 patients in whom the outcome was noted died. All surviving patients had received penicillin.

Bacteremia and cardiovascular infection

Bacteremia associated with *P. multocida* infections probably occurs more frequently than is commonly appreciated. Forty-seven cases have been reported in the literature (10, 12, 13, 17, 19, 23, 32, 37, 46, 56, 58, 60, 61, 63, 75, 77, 82, 83, 85, 86, 88, 90, 96, 98, 104, 107, 111, 115, 122–124, 127, 132, 134, 135, 143, 151, 154, 158, 160, 170, and our case 31). In patients with bacteremia, localized sites of *P. multocida* infection were identified as 88% of cases and were most often intra-abdominal infection, meningitis, pneumonitis, wound infection, arthritis, or bursitis (Table 6). Bacteremia accom-

TABLE 6. Localized sites of *P. multocida* infections in patients with *P. multocida* bacteremia*

Site	No. of Patients
Abdomen	9
Meninges	9
—sole site 5	
—with second site (pharynx (2), lung, umbilicus) 4	
Lung	6
Skin	5
Joint or bursa	4
Endocardium	2
Bone	2
Subdural space and pharynx	1
Joint and pleural space	1
Epiglottis	1
Endometrium (neonatal sepsis)	1
Not reported	3
None known	3
Total	47

* Summary of reported cases including case 31 in current series.

panied meningitis, pneumonia, and septic arthritis in 53, 24, and 24% of cases, respectively. As well, hematogenously seeded septic arthritis (129), vertebral osteomyelitis with paravertebral abscess (32, 124), and subcutaneous abscesses (111) have been reported.

Liver dysfunction was a major associated factor in *P. multocida* sepsis and was present in 14 of the 47 bacteremic cases. Types of liver disease included cirrhosis of any etiology, hepatitis, and tumor infiltration. Bacteremia in patients with cirrhosis has followed animal bites or scratches (13, 85) or simply animal exposure (75, 111). Thirty-six percent of cirrhotic patients with *P. multocida* bacteremia died.

In the neonate, three cases of *P. multocida* sepsis, all fatal within the first 72 hours of life, have been reported (12, 86, 154). Possible sources of neonatal infection included chorioamnionitis in one instance and an intrauterine transfusion in another.

Endocarditis was a rare complication of *P. multocida* bacteremia. Only two well-documented cases have been reported (96, 143). "Pasteurella-like" organisms have been implicated in an additional six cases of endocarditis (70, 128, 165). Single cases of a mycotic aneurysm (127), infected intravascular graft (87), and purulent pericarditis (147) have been reported.

Central nervous system infection

Epidemiology and pathogenesis: P. multocida has been isolated as the etiologic agent in meningitis, brain abscess, and subdural empyema. Epidemiologic surveys have revealed 2 of 450 (27), 6 of 136 (81), and 2 of 26 (67) human isolates of *P. multocida* to have been obtained from patients with meningitis.

There are four mechanisms by which *P. multocida* appears to be able to invade the central nervous system: 1) direct inoculation by a deep animal bite (91); 2) contamination from contiguous infected wounds after trauma or neurosurgery (67); 3) extension from an adjacent infected site by retrograde spread through lymphatics or veins (71, 94, 157); and 4) bacteremic seeding of the meninges (60, 61, 98) or of a pre-existing intracranial hematoma (90).

Meningitis, general features: P. multocida meningitis (Table 7) is a disease that occurs at the extremes of age. Fifty percent of the cases involved infants under the age of one year. Another 30% of the cases have been in adults over age 60. Males and females were affected equally.

Presenting symptoms were typical of meningitis (159): poor feeding, irritability, and vomiting in infants; lethargy, decreased level of consciousness, and stiff neck in adults. Eighty-five percent of patients were febrile on presentation. Seizures prior to hospitalization occurred in 25% of patients. The only focal neurologic sign noted in any case was a sixth cranial nerve palsy (Table 7, case 3).

On laboratory examination peripheral leukocyte counts were greater than 10,500/mm^3 in 80% of cases. The cerebrospinal fluid (CSF) generally revealed a pyogenic formula with greater than 500 white blood cells/mm^3 with a polymorphonuclear predominance, low glucose, and elevated protein level. Two patients had elevated CSF pressures. In 80% of cases, gram-stained smear of CSF showed small gram-negative coccobacilli that were often mistaken for either *Haemophilus influenzae* or *Neisseria meningitidis*. Bacteremia was documented in 53% of the cases.

Neurologic complications included seizures (Table 7, cases 3 and 11) and hemiparesis (Table 7, case 15). Permanent neurologic sequelae in survivors occurred only in case 15 (Table 7), in whom a mild residual hemiparesis remained at the time of discharge from the hospital. Pathologic findings were present in the central nervous system in three of four patients dying of meningitis and included fibropurulent meningeal exudate with congestion of the cerebral cortical veins (Table 7, cases 1 and 3), cerebral hemorrhagic infarction (Table 7, case 3), and subarachnoid hemorrhage (Table 7, case 6).

Successful treatment regimens included either penicillin or ampicillin, often combined with chloramphenicol. Duration of treatment ranged from 10–30 days (mean, 16 days). Mortality was high: 6 of 17 patients died, all within 72 hours of hospitalization.

M.G.H. Case 31—Meningitis: M.H. was admitted to the Mas-

TABLE 7. Meningitis caused by *P. multocida*

Case Number	Reference Year	Age Sex	Animal Exposure	Culture Source	Initial Lumbar Puncture	Treatment	Course
1	Lewis 1953	60 F	Cats	CSF, blood	WBC 580 (84P)*; Gram stain positive	Penicillin	Died—3 hours
2	Ewan 1955	10 M	Cats	CSF	WBC 3,000 (90P); glucose 55, protein 93	Penicillin/streptomycin/ sulfadiazine	Recovered
3	Swartz 1959	83 M	None	CSF, blood	WBC 5,200 (95P); glucose 25, protein 395; Gram stain positive	Penicillin/chloramphenicol/streptomycin	6th cranial nerve palsy; seizures; died—72 hours
4	Talbot 1960—See Whitmore	75 F	Cat scratch	CSF	WBC 2,000 (95P); Gram stain positive	Not recorded	Died—72 hours
5	Whitmore 1963	6 mo F	Dogs	CSF	WBC 20,000 (98P); glucose 14, protein 80; Gram stain positive	Penicillin/sulfadiazine/ chloramphenicol	Recovered
6	Bates 1965	64 hr M	Not recorded	CSF, blood, pharynx	WBC (numerous); glucose 8, protein 192; Gram stain positive	Penicillin/kanamycin	Subarachnoid hemorrhage; died—24 hours
7	Easton 1970	56 M	None	CSF	WBC 50,000 (mostly P); protein 500; Gram stain positive	Penicillin/chloramphenicol/sulphadimidine/ cloxacillin	Recovered
8	Repice 1975	1 mo	Cats	CSF, blood, pharynx	WBC 6,592 (60P); glucose 1, protein 315; Gram stain positive	Ampicillin/kanamycin/ cephalothin	Recovered
9	Slack 1975	5 mo M	None	CSF	WBC 100 (90P) glucose 2, protein 120, Gram stain positive	Ampicillin	Died—72 hours
10	Bhave 1977	7 wk M	Dogs	CSF, blood	WBC 3,000 (95P); glucose 20, protein 12; Gram stain positive	Ampicillin/gentamicin	Recovered
11	Frutos 1978	25 d	Dogs	CSF, blood, umbilicus	WBC 6,775 (89P); glucose 1, protein 160; Gram stain positive	Ampicillin/gentamicin	Seizures; recovered
12	McCue 1979	16 F	Rabbit	CSF, blood	WBC 18,000 (90P); glucose 12, protein 102; Gram stain positive	Mannitol, corticosteroids, penicillin/chloramphenicol	Recovered
13	Furie 1980	78 F	Cats	CSF, blood, lung	WBC 2 (100M)†; glucose 57, protein 28; Gram stain negative	Ampicillin	Died—8 hours
14	Smith 1980	35 M	Cats	CSF	WBC 870P; protein 30; Gram stain negative	Ampicillin	Recovered
15	Adenuga 1981	7 mo M	None	CSF	WBC 1,000 (80P); glucose 25, protein 300; Gram stain positive	Ampicillin/chloramphenicol, phenobarbitol	Recovered; residual hemiparesis
16	Belardi 1982	10 mo M	Dog bite	CSF	WBC 3,270 (95P); glucose 20, protein 171; Gram stain negative	Ampicillin/chloramphenicol	Recovered
17	Present report	7 wk F	Cats	CSF, blood	WBC 5 (100P); glucose 70, protein 30; Gram stain negative	Ampicillin/chloramphenicol	Recovered

CSF-cerebrospinal fluid, M-monocytes, WBC-white blood cells.
Glucose and protein levels in mg/dl.
* % polymorphonuclear leukocytes.
† % mononuclear cells.

sachusetts General Hospital at 7 weeks of age following a grand mal seizure. She had been born after a normal, full-term pregnancy. There was no history of neonatal illnesses, birth complications, fever, vomiting, irritability, rash, or cough. The patient had been exposed to three cats, but there was no history of bites or scratches.

Physical examination revealed a temperature of 38.2°C, pulse rate of 110/min, and respiratory rate of 60/min. There was a grade II/VI systolic murmur. Neurologic examination revealed an irritable infant with a supple neck, soft fontanelles, intact cranial nerve function, and active movement of all extremities.

On laboratory examination the leukocyte count was 12,300/mm^3 (35% polymorphonuclear cells, 23% band forms), and the blood glucose was 145 mg/dl. Examination of CSF showed 8 RBC/mm^3, 5 polymorphonuclear cells/mm^3, a glucose concentration of 70 mg/dl, and a protein concentration of 30 mg/dl; no organisms were seen on a gram-stained smear of the CSF.

Treatment was initiated with intravenous phenytoin, ampicillin (400 mg/kg/d), and chloramphenicol (100 mg/kg/d). Cultures of the blood and CSF grew *P. multocida* susceptible to penicillin and chloramphenicol. Seizures recurred on day three and were controlled by phenobarbitol. On the fourth day, hypertension and weight gain were noted. Laboratory studies were consistent with the syndrome of inappropriate secretion of antidiuretic hormone (SIADH), and the patient was treated with chlorothiazide and fluid restriction. Defervescence took place after 4 days of treatment, no additional seizures occurred, and the SIADH resolved. Antibiotic treatment consisted of intravenous chloramphenicol for 4 days and intravenous ampicillin for 18 days. Ampicillin was discontinued when neutropenia, thought to have been ampicillin-induced, developed. Examination of CSF on days 11 and 20 revealed two and then four leukocytes (all lymphocytes), normal glucose and protein concentrations, and negative cultures. Neurologic and auditory testing revealed no sequelae. The patient was discharged well on the 24th hospital day.

Comment: This case is typical of reports in the literature: The patient was under one year of age, there was a history of animal exposure without known bites or scatches, and the patient presented with central nervous system signs (seizures) and fever. Although the CSF usually contains more than 500 leukocytes/mm^3, a low glucose concentration, and an elevated protein concentration, our patient together with case 13 (Table 7) illustrate the fact that meningitis can occur with few leukocytes and normal protein and glucose levels in the CSF. This case is the first report of probable SIADH occurring in *P. multocida* meningitis. As in all but one of the previously reported cases of *P. multocida* meningitis, persistent neurologic sequelae were not observed.

Brain abscess: Five cases of brain abscess have been reported (Table 8). In three of these (71, 94, 157) cerebellar abscesses developed in the setting of chronic otitis media and mastoiditis. In two of the three patients, the development of the cerebellar abscess was preceded by surgery, a tonsillectomy and adenoidectomy in one case (71) and a mastoidectomy in the other (157). In the fourth case, a temporal lobe abscess occurred in association with chronic mastoiditis and a glomus jugulare tumor (169). In the fifth case, a cerebral abscess followed several lacerations of the head with penetration of the dura by a dog bite (91).

Presenting symptoms included fever, projectile vomiting, headache, and confusion. Physical examination often revealed nuchal rigidity, decreased level of consciousness, and focal neurologic defects consisting of lateralizing weakness. The CSF findings in the single instance reported (94) included polymorphonuclear pleocytosis, a low glucose concentration, and a high protein level. In more recent cases abscesses have been demonstrated by pneumonencephalography (94), brain scan and angiography (91), or computed tomography (169).

Treatment consisted of drainage and antibiotic administration in all cases. One patient died (71), and complications in one case each included slow healing (157) and persisting cerebellar signs (94).

Subdural empyema: Two patients with subdural empyema have been reported (Table 8). One patient, a 44-year-old woman who frequently kissed her dog and two cats, developed a subdural empyema several weeks after an ethmoid polypectomy (152). The other patient, a 62-year-old man with a history of alcohol abuse, had positive cultures for *P. multocida* from pharynx and blood and was thought to have seeded hematogenously a subdural hematoma (90).

Presenting symptoms included severe headache in both patients, a seizure in one, and altered consciousness in the other. On physical examination both were febrile (>38.5°C), there were no focal neurologic findings, and one had meningismus. Examination of the CSF showed the presence of leukocytes in both cases, but gram-stained smears revealed no organisms, and cultures were negative. The diagnosis was made in both cases by demonstration of a subdural fluid collection by computed tomography and by growth of *P. multocida* from aspirated material. Treatment consisted of drainage of the empyema and antibiotic treatment with intravenous penicillin or ampicillin. Both patients recovered.

Intra-abdominal infections

P. multocida has been found in a variety of intra-abdominal infections, including spontaneous bacterial peritonitis, peritonitis due to a ruptured viscus, intra-abdominal abscesses, and postoperative wound infections.

Seven cases of spontaneous bacterial peritonitis have been reported, all in patients with either histologically proved (five cases) or suspected (two

TABLE 8. Parameningeal infections (brain abscess/subdural empyema) caused by *P. multocida*

Case Number	Reference Year	Age Sex	Animal Exposure	Culture Source	Initial Lumbar Puncture	Treatment	Outcome
1	Larsen 1969	14 F	Not recorded	Cerebellar abscess	WBC 1,800 (76P)*; glucose 20, protein 109;† culture negative	Drainage, mastoidectomy, ampicillin/chloramphenicol/oxacillin/sulfadiazine	Recovered; neurologic deficits
2	Klein 1978	19 mo F	Dog bite	Cerebral abscess	Culture negative	Drainage, antibiotics	Recovered
3	Harris 1953	11	Cats	Cerebellar abscess, mastoid	WBC 0; Culture negative	Drainage, mastoidectomy, penicillin/chlortetracycline	Died—10 days
4	Svendson 1947	18 M	None	Cerebellar abscess	NR	Drainage, penicillin/sulfadiazine	Recovered
5	Whittle 1982	65 F	Not recorded	Cerebral abscess	NR	Drainage, mastoidectomy, metronidazole/penicillin	Recovered
6	Stern 1981	44 F	Cats and dogs	Subdural empyema	WBC 21 (5P); glucose 62, protein 39	Drainage, penicillin/chloramphenicol	Recovered
7	Khan 1981	62 M	Dogs	Subdural empyema, pharynx, blood	WBC 491 (72P); glucose 94, protein 143; Gram stain negative; culture negative	Ampicillin, mannitol, drainage, antiseizure medications	Recovered; seizure in hospital

WBC-white blood cells, NR-not recorded.
* % polymorphonuclear leukocytes.
† Glucose and protein levels in mg/dl.

cases) hepatic cirrhosis, and with histories of considerable ethanol intake. The seven cases of spontaneous bacterial peritonitis fit into two clinical patterns: four patients (46, 83, 123, 160) entered the hospital afebrile with bleeding from the upper gastrointestinal tract, underwent endoscopy, and developed fever and peritonitis 1 to 3 days later. Three patients (63, 122) were septic on admission to the hospital with fever, elevated leukocyte counts, and in two of three cases hypotension. One might speculate that in the first four patients *P. multocida* spontaneous peritonitis resulted from the endoscopic procedure. Instrumentation of a patient whose mouth or pharynx was colonized with *P. multocida* might have caused a transient bacteremia either from trauma to the upper airway or from organisms introduced into a damaged digestive tract. Bacteremia then might have resulted in seeding of the ascitic fluid. Alternatively, *P. multocida* might have spread directly through altered gastrointestinal mucosa into the peritoneal cavity.

Physical findings included fever (>38.3°C in all seven cases), abdominal tenderness (three cases), hypotension (three cases), and altered consciousness (one case). Abdominal paracentesis was reported in five cases and revealed 760 to 19,700 leukocytes/mm^3 (75–100% polymorphonuclear cells) and protein of 0.7 to 1.0 g/dl. Gram-stained smears of peritoneal fluid showed organisms in one of five cases. *P. multocida* was isolated from blood and ascites in four cases, ascites only in one case, and blood only in two cases. Four of the seven patients died.

In epidemiologic studies (67, 81) *P. multocida* has been isolated from patients with appendicitis with or without perforation. Case reports (43, 86, 100) did not suggest that these infections differed in severity from appendicitis associated with other organisms.

P. multocida has been isolated from the peritoneal cavity of patients with duodenal perforation (172) and a Mallory-Weiss tear (61). It also has been isolated from retrocecal (172), omental (75), and liver abscesses (54). In epidemiologic surveys (27, 81) and case reports (22) *P. multocida* has been implicated as a cause of postoperative wound infection, especially after colonic or appendiceal surgery.

In a single case (26), a symptom complex of nausea, vomiting, diarrhea and fever in a young child was attributed to intestinal infection with *P. multocida*. The organism was isolated in heavy growth from the patient's stool, and the symptoms resolved with treatment with a combination of ampicillin and chloramphenicol.

Genitourinary tract infections

General features: P. multocida has been isolated from the cervical or vaginal drainage of five women, four of whom had cancer of the reproductive tract or dysfunctional uterine bleeding (81). A case of cervicitis in a patient with cervical cancer has been reported (172). *P. multocida* has also been isolated from Bartholin gland abscesses and an endometrial polyp (81). A single case of chorioamnionitis with neonatal sepsis and death has been reported (154). Probable epididymitis has been reported in a male infant (18).

P. multocida can cause both upper and lower urinary tract infections. In two patients from whose urine *P. multocida* was isolated in pure culture, pyuria cleared with penicillin therapy (93). An additional five cases in which *P. multocida* was isolated from the urine included one man with pyelonephritis and four women with either pneumonia, dysuria, chronic cystitis, or carcinoma of the bladder with nephritis (81). *P. multocida* has been isolated from renal abscesses in three patients (50, 148, 161). In the one case in which clinical details were described (50), the patient had received radiation for cervical carcinoma, had had bladder reflux into the ureter, and had required cutaneous ureterostomy and ampicillin for effective treatment.

M.G.H. Case 32–Colonization of an ileal loop: F.B., an 11-year-old girl born with an extrophic bladder, was admitted to the hospital for replacement of an ileal loop with a colonic conduit. She had a history of recurrent urinary tract infections. On admission she was afebrile and asymptomatic. Physical examination revealed an enlarged spleen and palpable left kidney. On laboratory examination, the leukocyte count was 5,600/mm^3. Urinalysis revealed 5–10 white blood cells per high powered microscopic field. On culture, the urine grew abundant *P. multocida* and *Proteus rettgeri*. An intravenous pyelogram showed a small scarred right kidney consistent with chronic pyelonephritis and an enlarged left kidney.

The patient remained asymptomatic. Nine days after admission a colonic conduit was constructed, and the patient received a short course of cephalothin and gentamicin intravenously followed by oral sulfasoxazole. Subsequent urine cultures were sterile.

Comment: This case is the second report of colonization of an ileal loop with *P. multocida* (9).

Ocular infections

General features: Ocular infections due to *P. multocida* have included conjunctivitis (81), a corneal ulcer following an eye being brushed by a dog (130), and endophthalmitis following a cat scratch (62, 155).

M.G.H. Case 30—Endophthalmitis: J.W., a 10-year-old boy, was admitted to the Massachusetts Eye and Ear Infirmary following a cat scratch to the cornea of his left eye. Presenting complaints included decreased vision and pain in the involved eye. On physical examination the child was afebrile, the lids were intact, and two corneal lacerations with prolapse of the iris were present. Blood was noted in the anterior chamber, but there

were no signs of infection. Later that day the child underwent surgical repair of the corneal lacerations and vitrectomy. At the time of surgery excessive inflammation was noted, cultures were taken, and a single subconjunctival dose of gentamicin was administered. Postoperative antibiotics included intravenous gentamicin and oxacillin, gentamicin eye drops, and erythromycin eye ointment. *P. multocida* was cultured from the vitreal fluid and iris tissue. Antibiotics were changed to intravenous ampicillin and cephalothin. Intravenous antibiotics were administered for a total of 10 days, and the patient was discharged on a regimen of oral ampicillin. Vision at discharge was 20/70. Subsequently vision with a corrective lens was 20/30.

Comment: This case is the first report of *P. multocida* endophthalmitis in which vision was preserved. The case emphasizes the need to consider *P. multocida* as a potential pathogen in infections following animal bites, scratches, and abrasions about the eye. The case also demonstrates that *P. multocida* endophthalmitis may be successfully treated with vigorous and rapid surgical intervention in combination with administration of appropriate antibiotics.

Diagnosis

Proper treatment of *P. multocida* infection requires accurate diagnosis. Francis et al (58) detailed three reasons why the diagnosis may be delayed or overlooked.

1. The diagnosis is not suspected: *P. multocida* should be considered as a possible etiologic agent in any infection following an animal bite or cat scratch. Initial therapy of such infections should include agents active against *P. multocida.* The evaluation of septic arthritis occurring in the setting of underlying joint disease should include questioning of the patient about animal exposure and trauma and a careful search for bites or scratches of the affected extremity. *P. multocida* should be included among the bacterial species considered as possible etiologies of either spontaneous peritonitis or bacteremia in patients with hepatic cirrhosis or severe liver disease, especially if there is a history of exposure to animals.

2. Gram-stained smears are not done or are misinterpreted: *P. multocida* appears as a small, gram-negative rod, often with bipolar uptake of dye. When the infecting organism is *P. multocida*, it is seen in stained smears of CSF in 80% of cases of meningitis, in joint fluid in 50% of cases of septic arthritis, in pleural fluid in up to 50% of patients with empyema, and in ascitic fluid in 20% of cases of spontaneous bacterial peritonitis. On gram-stained smears of body fluids, *P. multocida* is frequently mistaken for *Haemophilus influenzae*, Acinetobacter spp., *Neisseria meningitidis*, or *Neisseria gonorrheae.*

3. Incorrect identification in the bacteriology laboratory: *P. multocida* is a distinctive organism, but some difficulty may be encountered in its identification in the microbiology laboratory. Excellent growth on blood agar, failure to grow on MacConkey's agar, and morphology on Gram-stain, coupled with biochemical tests, should allow proper identification. Clinical laboratories using commercial test systems must exercise caution as the Minitek, the API, and Oxi/Ferm systems have been reported to identify only 11%, 68% and 81%, respectively, of *P. multocida* isolates tested (117). The lack of sensitivity of the Oxi/Ferm system has been confirmed (49).

Treatment

Penicillin is the drug of choice for *P. multocida* infections because of efficacy, safety, penetration into the CSF and other body fluids, and low cost. In serious infections susceptibility testing of isolates should be performed because penicillin resistance has been found in *P. multocida* strains isolated from two cases of human infection (26, 54) and in 16 to 22% of strains isolated from cattle and swine (42, 57).

P. multocida infections are not infrequently treated with inappropriate antibiotics. For example, in our series of 34 patients, 18 patients received appropriate therapy with a penicillin or a tetracycline, and 8 patients received adequate therapy with parenteral cephalosporin. Five patients, however, received inappropriate therapy with oral erythromycin, oral cephalosporin, a semisynthetic penicillin, or clindamycin. In the remaining three patients, systemic antibiotic therapy was not warranted.

In order to aid the clinician in treating established *P. multocida* infection, we offer the following guidelines:

Local wound infections: Patients at high risk for complications should be admitted to the hospital and treated with high doses of intravenous antibiotics because of the potential for bone and joint infection. High risk groups include patients with evidence of tenosynovitis; severe joint disease or prostheses proximal to the site of infection; conditions altering host defenses such as renal failure, hepatic cirrhosis, or corticosteroid use; penetration of a joint by tooth or claw; and closed space infections of the hand or foot.

Outpatient oral antibiotic therapy may be reasonably employed initially in patients with simple cellulitis, but close followup is mandatory. Local wound care, tetanus prophylaxis, and rabies prophylaxis (if indicated) are key elements in treatment of all animal bites. For oral therapy, penicillin VK at full doses (500–750 mg orally four times daily

in adults) is the drug of choice. If the patient is allergic to penicillin, tetracycline is an alternative. In patients unable to take either penicillin or tetracycline, chloramphenicol may be effective therapy. If *Staphylococcus aureus* is isolated or gram-positive cocci in clusters are observed on Gram stain, hospitalized patients can receive a parenteral cephalosporin, but no single acceptable oral drug provides reliable coverage of both *S. aureus* and *P. multocida*.

Bone and joint infections: Septic arthritis should be treated by intravenous antibiotics in high doses and repeated closed joint aspirations. In most cases a three-week course of antibiotics is adequate. For prosthetic joint infections of the knee, one may attempt to treat with antibiotics alone without removal of the prosthesis, but close follow-up is crucial as retreatment and prosthesis removal may be necessary to effect cure. Osteomyelitis should be treated with a four- to six-week course of parenteral antibiotics. The role of surgery in *P. multocida* bone infections is unclear. All bone and joint infections of the fingers require vigorous therapy because of the high incidence of permanent sequelae.

Respiratory tract infections: P. multocida is occasionally found as a commensal with underlying pulmonary disease, and in these patients no treatment other than routine pulmonary care is necessary. Uncomplicated tracheobronchitis, sinusitis, or other upper respiratory tract infections should be treated with oral penicillin or tetracycline. Serious lower respiratory tract infections should be treated with intravenous antibiotics. If the differential diagnosis includes pulmonary infections due to *P. multocida* or *H. influenzae*, ampicillin or amoxicillin are reasonable antibiotics for treatment; in patients allergic to penicillin, cefamandole (depending on the nature of the penicillin allergy) or chloramphenicol might be used.

Central nervous system infections: Penicillin is the drug of choice in the treatment of *P. multocida* meningitis because of its excellent penetration into the CSF in the presence of inflamed meninges. In patients with a history of nonlife-threatening allergic reaction to penicillins, moxalactam may prove useful because bactericidal drug levels will be achieved in the CSF based on studies *in vitro*. Chloramphenicol may achieve bactericidal concentrations in the CSF against some strains of *P. multocida* but only bacteriostatic concentrations against other strains, based on known CSF penetration of the drug (131, 173) and *in vitro* susceptibility data (see section on Antibiotic Susceptibility Testing). Drainage is indicated for patients with brain abscess or subdural empyema. Associated sites of infection (mastoiditis or sinusitis) should be sought in any patient with an intracranial infection and without a history of penetrating cranial trauma.

Intra-abdominal infections: Intra-abdominal infections due to *P. multocida* can be treated with several regimens that are also effective against bowel flora. These include ampicillin and gentamicin, penicillin and chloramphenicol, or cefoxitin with or without an aminoglycoside. The combination of clindamycin and an aminoglycoside should not be used because many strains of *P. multocida* are not susceptible to either of these drugs *in vitro*.

Renal infections: Uncomplicated lower urinary tract infections may be treated with oral penicillin, ampicillin or a tetracycline. Patients with *P. multocida* in the urine who exhibit systemic toxicity should be evaluated for the possibility of pyelonephritis or renal abscess.

Prophylactic antibiotics for animal bites or scratches: The role of prophylactic antibiotics in potentially infected animal bite wounds has been addressed in three prospective, double blind, placebo-controlled studies using either oxacillin (53) or penicillin (21, 36) orally for five days. None of the studies showed a statistically significant difference in rates of infection between the placebo-treated and antibiotic-treated groups, but the numbers of patients studied were small. Recommendations in the literature vary and include the use of penicillin in all animal bite wounds (65), oxacillin in high-risk wounds such as puncture wounds or bites of the hand (36), or no antimicrobial therapy in the absence of established infection (53). The exact role of prophylactic antibiotics in the treatment of potentially infected animal-bite wounds is yet to be determined. Additional larger studies are necessary to clarify this issue and possibly to define subgroups (such as puncture wounds from cat bites, hand wounds, and facial injuries) in which prophylactic antibiotics are more likely to be of value.

For all animal bites local wound care with careful attention to debridement, copious irrigation, and close follow-up is crucial in minimizing infection (34, 35, 41, 51, 53, 68).

Summary

Pasteurella multocida, a small, gram-negative coccobacillus, is part of the normal oral flora of many animals, including the dog and cat. *P. multocida* is the etiologic agent in a variety of infectious disease syndromes. We have reported 34 cases of infection caused by *P. multocida* and have reviewed the English literature.

P. multocida infections may be divided into three broad groups:

1. Infections resulting from animal bites and scratches: The most common infections caused by *P. multocida* are local wound infections following animal bites or scratches. Cats are the source of infection in 60 to 80% of cases and dogs in the great majority of the remainder. Local infections are characterized by the rapid appearance of erythema, warmth, tenderness, and frequently purulent drainage. The most common local complications are abscess formation and tenosynovitis. Serious local complications include septic arthritis proximal to bites or scratches, osteomyelitis resulting from direct inoculation or extension of cellulitis, and the combination of septic arthritis and osteomyelitis, most commonly involving a finger or hand after a cat bite.

2. Isolation of P. multocida from the respiratory tract: The isolation of *P. multocida* from the respiratory tract must be interpreted differently than its isolation from other systemic sites. Most commonly *P. multocida* found in the respiratory tract is a commensal organism in patients with underlying pulmonary disease, but serious respiratory tract infections including pneumonia, empyema, and lung abscesses may develop. Most patients with respiratory tract colonization or infection have a history of animal exposure.

3. Other systemic infections: *P. multocida* is recognized as a pathogen in a variety of systemic infections including bacteremia, meningitis, brain abscess, spontaneous bacterial peritonitis, and intra-abdominal abscess.

P. multocida often acts as an opportunistic pathogen with a predilection for causing bacteremia in patients with liver dysfunction, septic arthritis in damaged joints, meningitis in the very young or elderly, and pulmonary colonization or invasion in patients with underlying respiratory tract abnormalities.

The failure to diagnose *P. multocida* infection correctly is most commonly due to the failure to include the organism in the differential diagnosis. *P. multocida* should be considered a potential etiologic agent of any local infection following cat or dog bites or cat scratches. Other reasons for incorrect diagnosis include misidentification on gram-stained smear or inadequate laboratory identification techniques.

Treatment of *P. multocida* infections includes drainage of local purulent collections and antibiotic therapy. Penicillin is the drug of choice. Alternative drugs include ampicillin, the parenteral cephalosporins, tetracycline, and chloramphenicol.

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