Clinical Features and Outcomes of *Pasteurella multocida* Infection

Antonio Giordano, MD, PhD, Toros Dincman, MD, PhD, Benjamin E. Clyburn, MD, Lisa L. Steed, PhD, and Don C. Rockey, MD

Abstract: *Pasteurella multocida*, a zoonotic infectious organism, has most often been described in patients after an animal bite. Here, we characterize the clinical features and outcomes of *P. multocida* infection in a large cohort of patients according to the presence or absence of an animal bite.

We retrospectively searched MUSC’s laboratory information system for all patients with positive *P. multocida* cultures from 2000 to 2014. Extensive data were abstracted, including clinical and outcome data. The Charlson comorbidity index (CCI) was used to assess comorbidities among patients.

We identified 44 patients with *P. multocida* infections, including 25 with an animal bite. The average age was 64 years and the majority of patients were women (N=30). There was no difference in age and sex distribution among those with and without a bite (P=0.38 and 0.75, respectively). A CCI ≥ 1 was significantly associated with the absence of a bite (P = 0.006). Patients presenting without a bite were more frequently bacteremic (37% vs 4%, respectively, P = 0.001), and were hospitalized more often (84% vs 44%, respectively, P = 0.012). Of the 8 patients who required intensive care unit (ICU)-based care, 7 were non-bite-related. There were 4 deaths, all occurring in patients not bitten.

*P. multocida* infections not associated with an animal bite were often associated with bacteremia, severe comorbidity(ies), immune-incompetent states, the need for ICU management, and were associated with substantial mortality.

(Medicine 94(36):e1285)

Abbreviations: CCI = Charlson comorbidity index, COPD = chronic obstructive pulmonary disease, ICU = intensive care unit, LOS = length of stay, MELD = Model for End-stage Liver Disease.

INTRODUCTION

*Pasteurella multocida* is a facultative anaerobic, fermentative Gram-negative coccobacillus found in the oropharynx of healthy animals, particularly cats, dogs, and pigs, as well as various wild animals.1,2 Cats and dogs have the highest carriage rates, at 70% to 90% and 20% to 50%, respectively.3 Human infections due to *P. multocida* have been tightly associated with animal exposure and usually involve soft-tissue sites after animal bites or scratches.4,5 Estimation of the prevalence of *P. multocida* infection in the United States is difficult. Roughly 300,000 (1%) annual visits to the emergency rooms in the United States are due to animal bites or scratch wounds.

In addition to not all of these lead to clinically relevant infections, when an infection occurs, *Pasteurella* species are isolated from some 50% of dog bites and 75% of cat bites.6 Thus, although serious infections and death from *P. multocida* infection in the United States are uncommon, this disease is important because of the pervasive nature of animal bites in the United States.

Of note, *P. multocida* can be isolated from the respiratory tract of humans, presumably as commensal organism. Serious respiratory tract infections including pneumonia, empyema, and lung abscesses are typically found in patients with underlying pulmonary disease. Despite the apparent commensal relationship between *P. multocida* and the respiratory tract, most patients with respiratory tract infection have a history of animal exposure.1,2,7–11 Of note appears to act as an opportunistic pathogen with a predilection for causing bacteremia in patients with liver dysfunction or in immuno-suppressed patients.1,2,8,9,12–19,21

Broad-spectrum antibiotics that target *Pasteurella*, as well as other Gram-negative and Gram-positive bacteria, are the preferred prophylaxis for animal bites, which tend to be polymicrobial in nature. A combination of amoxicillin and the β-lactamase inhibitor clavulanic acid, doxycycline plus metronidazole for patients with penicillin allergies, or clindamycin plus a fluoroquinolone (ciprofloxacin), or clindamycin plus trimethoprim-sulfamethoxazole for children, or clindamycin plus ceftriaxone for pregnant women are the recommended treatment regimens.22–24 Although there are a limited number of single case reports in the literature describing the clinical features and outcomes of patients presenting with systemic infection due to *P. multocida*, larger studies are lacking. We therefore examined patients at our institution with *P. multocida* infection, according to presence or absence of an animal bite.

METHODS

Study Design and Patients

This retrospective study was approved by the MUSC IRB (Pro00034870) and adhered to guidelines as set forth in the
Declarator of Helsinki. We searched MUSC’s microbiology laboratory information system for any patient with a positive \textit{P multocida} culture (reports from blood, sputum, urine, subcutaneous tissue, and other biologic tissue culture) from 2000 to 2014. We also performed an ICD-9 search for “\textit{Pasteurella multocida}” and/or “animal bite” through MUSC’s Clinical Data Warehouse to identify additional potential subjects. We collected demographic, extensive clinical data (history of present illness, whether an animal bite occurred or not, medical history, physical examination, days spent in the intensive care unit [ICU], laboratory and radiologic findings, respiratory therapy, length of stay [LOS], and outcome data), bacteriologic (see below) data, and type and duration of antibiotics from the medical record. An animal bite was defined as breaking of the skin by the teeth of an animal. Other traumatic exposures of humans to animals, such as a scratch, were also included in the group animal bite.

The validated Charlson comorbidity index (CCI) and the age-adjusted CCI were used to classify prognostic comorbidities among patients. 

Microbiology

Specimens other than blood were routinely inoculated directly onto chocolate agar, trypticase soy agar with 5% sheep blood, MacConkey agar, and trypticase soy agar with 5% sheep blood, colistin, and nalidixic acid and streaked for isolation. Plates were incubated for 36 to 48 hours at 37°C in CO₂. Organisms that were Gram-negative bacilli/coccobacilli that grew only on chocolate agar and sheep blood agar and were oxidase positive, catalase positive, and indole positive were further characterized using conventional biochemical methods. Beta lactamase testing was performed according to the manufacturer’s (BBL cefinase, BD Diagnostics, Sparks, MD) package insert.

Statistics

Demographic and clinical data were extracted and analyzed. Descriptive statistics including means, medians, frequencies, and percentages were used to summarize the data. A nonparametric test or \( \chi^2 \) (Fisher exact test in the case of small sample) was used to compare groups of continuous and categorical variables, respectively. All \( P \) values reported are 2-sided; a level of 0.05 was considered statistically significant. All data were analyzed with IBM SPSS Statistics v22.

RESULTS

We identified a total of 44 patients with \textit{P multocida} infections, 25 who had an animal bite (Table 1). The animals implicated included cats and dogs. The average age of patients in the cohort was 64 years and the majority of patients were women (n = 30, 68%). There was no difference in the age or sex distribution among those with and without an animal bite (\( P = 0.38 \) and 0.75, respectively). The most common source of infection was the skin, although in those without an animal bite, the bloodstream was the most common site of infection (Table 1). Isolation of \textit{P multocida} from the bloodstream and respiratory tract was more frequently associated with absence of animal bite; conversely, skin infections were strongly associated with an animal bite (\( P = 0.001 \)).

Among patients who presented with an animal bite, there was no correlation among comorbidity, source of infection, and inpatient hospital requirement. Patients presenting with a cat versus a dog bite were more frequently hospitalized (\( P = 0.029, \) Table 2). Patients presenting without an animal bite were more frequently hospitalized and had a longer LOS compared with patients who had a bite (84% vs 44% and 19.7 vs 5.1 days, respectively, \( P = 0.012 \)). Of the 8 patients who required ICU care, 7 were non-bite-related (\( P = 0.014 \)).

\textit{P multocida} culture results were available for 39 of 44 patients. It was the sole organism recovered from blood or muscle cultures. In 3 of 4 (75%) respiratory cultures, \textit{P multocida} grew abundantly as the sole isolate; in the fourth culture, \textit{P multocida} was grown in equal abundance with usual oral flora. Eleven of 20 (55%) skin cultures—3 non-bite-related, 8 bite-related—grew \textit{P multocida} as the sole isolate. Not unexpectedly, 7 (35%) skin cultures grew \textit{P multocida} with organisms consistent with usual skin flora in varying concentrations. Of these, 2 were non-bite-related, whereas 5 were in animal bites. Interestingly, 1 non-bite-related skin culture grew equal amounts of \textit{P multocida} and methicillin-susceptible \textit{Staphylococcus aureus}, whereas another non-bite-related skin culture grew equal amounts of \textit{P multocida} and methicillin-resistant \textit{S aureus} and a lesser amount of a mixture of Gram-positive and Gram-negative flora.

As Gram stains are not typically useful in identifying \textit{Pasteurella} infection, Gram stains were not ordered in all patients. For specimens that were subjected to routine Gram stains, 7 of 32 Gram stains showed only Gram-negative bacilli, whereas 3 additional stains showed Gram-negative bacilli mixed with Gram-positive cocci. Only 4 specimens with Gram stains showing Gram-negative bacilli were from patients with animal bite. Sixteen Gram stains showed no microorganisms at all.

\textit{Pasteurella} sp susceptibility testing, including the recommendation for beta lactamase testing, became standardized in 2006. Thus, beta lactamase results were available for 32 of 39 cultures; 69% were beta lactamase-negative and 13% were beta lactamase-positive. There was no apparent difference between beta lactamase positivity and the type or severity of infection (\( P = 0.99, \) Table 1).

Sixty-three percent of patients were affected by at least 1 disease that could lead to an immunocompromised status. Notably, a CCI \( \geq 1 \) was significantly associated with the absence of bite (\( P = 0.006 \)). The most common comorbidity was chronic lung disease (\( N = 7 \)), followed by malignancy (\( N = 6 \)). Patients without an animal bite presenting with CCI \( \geq 1 \) and non soft-tissue infections required hospitalization more frequently (Table 3). In the 2 patients presenting with cirrhosis, Model for End-stage Liver Disease (MELD) scores were 29 and 33, respectively, and were both Child-Pugh score C, signifying advanced decompensated chronic liver disease; these patients are well known to be susceptible to infection. In patients with bloodstream infections, cancer was the most common comorbidity (4/8), followed by respiratory diseases and cerebrovascular disease (2/8 for both categories). Chronic obstructive pulmonary disease (COPD) was present in 3 of 4 patients presenting with \textit{P multocida} pneumonia and no animal bite. Interestingly, 3 of 4 patients with a deep muscle abscess were affected by diabetes.

Patients with a non-animal bite \textit{P multocida} infection were more often cared for in an ICU setting (1/25 [4%] for animal bite vs 7/19 [37%] for non-animal bite, Table 1). Among those who were treated in the ICU, the most common comorbidities were cerebrovascular disease (3), cirrhosis (2), malignancy (2), COPD (2), end-stage renal disease (1), and dementia (1). For those patients, bloodstream and respiratory tract infections were the most common source of infection (Table 3).
The mean LOS for patients presenting with an animal bite was 5.1 days (2–11, range), and the mean LOS in absence of an animal bite was 19.7 days (3–180, range). There were 4 deaths, all occurring in patients without animal bite. The mortality rate for patients with *P. multocida* infection in absence of animal bite was 21%, and all deceased patients presented with serious and multiple comorbidities (at least a CCI of 3, or an age-adjusted CCI of 4) and often an immune-incompetent state. Either cirrhosis or metastatic cancer was found in all fatal cases (Table 3).

Most of the patients presenting with soft-tissue infection secondary to animal bite received amoxicillin with the β-lactamase inhibitor clavulanic acid oral therapy for 10 to 14 days. In patients with a penicillin allergy, an alternative regimen with clindamycin or sulfamethoxazole trimethoprim was chosen (Table 2). Almost all patients requiring hospitalization, regardless of presence or absence of an animal bite, received intravenous antibiotics. Antibiotics given varied, although for those presenting without an animal bite, a more aggressive approach was preferred (typically double coverage with vancomycin and 3rd-generation cephalosporin). The duration of treatment for a patients without an animal bite tended to be longer than those with an animal bite (Table 3).

### DISCUSSION

In this single-institution study, we have reported on the clinical features and outcomes of a large cohort of patients presenting with *P. multocida* infection. Of the 44 patients identified, 19 (43%) presented without a documented animal bite or scratch. Although many of the infections associated with animal bites were confined to soft tissues, isolation of *P. multocida* from the bloodstream and respiratory tract was more frequently associated with absence of animal bite. A key finding of our study was that infections without a bite history seemed to occur in patients with serious comorbidities who often had an immune-compromised state. This group of patients were also more frequently hospitalized, more often required ICU-based care, and had a higher LOS. The mortality rate for patients without an animal bite was also significantly higher than those with an animal bite.

### TABLE 1. Patient Clinic Characteristics According to the Presence or Absence of an Animal Bite

| Patient Characteristics | Total (n = 44) | Animal Bite (n = 25) | No Animal Bite (n = 19) | P |
|-------------------------|--------------|---------------------|------------------------|---|
| Median age in years (25th and 75th percentiles) | 64 (52–75) | 66 (50–77) | 64 (50–77) | 0.38 |
| Sex | 30 (68%) | 18 (72%) | 12 (63%) | 0.75 |
| Male | 14 (32%) | 7 (28%) | 7 (37%) | 0.006 |
| CCI | 0 | 20 (45%) | 16 (64%) | 4 (21%) | 0.22 |
| ≥1 | 24 (55%) | 9 (36%) | 15 (79%) | |
| Age adjusted CCI | 0–2 | 22 (50%) | 15 (60%) | 7 (37%) | 0.001 |
| ≥3 | 22 (50%) | 10 (40%) | 12 (63%) | 0.099 |
| Specimen source | Blood | 8 (18%) | 1 (4%) | 7 (37%) | 0.012 |
| Peritoneal fluid | 1 (2%) | — | 1 (5%) | |
| Muscle abscess | 4 (9%) | 2 (8%) | 2 (11%) | |
| Synovial fluid | 2 (5%) | 1 (4%) | 1 (5%) | |
| Respiratory | 4 (9%) | — | 4 (21%) | |
| Skin | 24 (55%) | 21 (84%) | 3 (16%) | |
| n/r | 1 (2%) | — | 1 (5%) | |
| Beta-lactamase test | Positive | 5 (11%) | 3 (12%) | 2 (11%) | 0.99 |
| Negative | 27 (61%) | 15 (60%) | 12 (63%) | |
| n/r | 7 (17%) | 4 (16%) | 3 (15%) | |
| n/a | 5 (11%) | 3 (12%) | 2 (11%) | |
| Hospital setting | Outpatient | 17 (39%) | 14 (56%) | 3 (16%) | |
| Inpatient | 27 (61%) | 11 (44%) | 16 (84%) | 0.014 |
| Required ICU | 8 (18%) | 1 (4%) | 7 (37%) | 0.14 |
| Antibiotic regimen | Oral antibiotic only | 13 (30%) | 8 (32%) | 5 (26%) | 0.012 |
| IV antibiotic | 21 (48%) | 9 (36%) | 12 (63%) | 0.55 |
| n/r | 10 (22%) | 8 (32%) | 2 (11%) | |
| Surgical intervention | 19 (43%) | 12 (48%) | 7 (37%) | |
| LOS, days | Mean, SD (range) | 13.5, 34.2 (2–180) | 5.1, 2.8 (2–11) | 19.7, 44.6 (3–180) | 0.001 |
| Mortality | 4 (9%) | 0 | 4 (21%) | |

CCI = combined comorbidity index, ICU = intensive care unit, LOS = length of stay, n/a = not available, n/r = not reported, SD = standard deviation.
| Age | Comorbidities | CCI | Animal Bite | Location of Infection | Hospital Days | Required Surgery | IV Antibiotic Regimen | Oral Antibiotic Regimen | Antibiotic Duration |
|-----|---------------|-----|-------------|----------------------|--------------|-----------------|----------------------|------------------------|---------------------|
| 52  | None          | 0   | Cat         | Skin                 | 4            | Skin            | Vancomycin + Ampicillin sulbactam | Amoxicillin clavulanate + Sulfamethoxazole trimethoprim | 4 + 10               |
| 78  | None          | 0   | Cat         | Skin                 | 2            | Skin            | Ampicillin sulbactam             | Amoxicillin clavulanate                          | 1 + 10               |
| 75  | Diabetes, colon cancer, lupus | 5   | Dog         | Skin                 | 5            | Skin            | Ampicillin sulbactam             | Amoxicillin clavulanate                          | 5 + 14               |
| 53  | None          | 0   | Dog         | Skin                 | 4            | Skin            | Ampicillin sulbactam             | Amoxicillin clavulanate + Ciprofloxacin           | 4 + 10               |
| 85  | Diabetes, peripheral vascular disease | 2   | Cat         | Skin                 | 11           | None            | Ceftriaxone                      | Amoxicillin clavulanate                          | 11 + 7               |
| 66  | Diabetes, myocardial infarction | 2   | Dog         | Skin                 | 4            | Skin            | Clindamycin                      | Clindamycin                                        | 4 + 10               |
| 41  | None          | 0   | Dog         | Skin                 | 0            | None            | No IV antibiotics               | Amoxicillin clavulanate + Sulfamethoxazole trimethoprim | 14                  |
| 68  | None          | 0   | Cat         | Skin                 | 4            | Skin            | No IV antibiotics               | Amoxicillin clavulanate + moxifloxacin            | 14                  |
| 81  | COPD           | 1   | Dog         | Skin                 | 0            | Skin            | No IV antibiotics               | Amoxicillin clavulanate                          | 10                  |
| 53  | COPD           | 1   | Cat         | Skin                 | 0            | None            | No IV antibiotics               | Amoxicillin clavulanate                          | 10                  |
| 63  | None          | 0   | Cat         | Skin                 | 0            | None            | No IV antibiotics               | Amoxicillin clavulanate                          | 7                   |
| 19  | Asthma         | 1   | Cat         | Skin                 | 2            | Skin            | No IV antibiotics               | Amoxicillin clavulanate                          | 14                  |
| 76  | None          | 0   | Cat         | Skin                 | 0            | Skin            | No IV antibiotics               | Sulfamethoxazole trimethoprim                    | 10                  |
| 30  | None          | 0   | n/r          | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 45  | None          | 0   | Cat         | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 57  | None          | 0   | n/r          | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 67  | None          | 0   | n/r          | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 67  | None          | 0   | n/r          | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 76  | None          | 0   | n/r          | Skin                 | 0            | None            | No IV antibiotics               | n/a                                                | n/a                 |
| 86  | Diabetes, chronic kidney disease | 2   | Dog         | Deep muscle abscess  | 0            | Abscess drainage | No IV antibiotics               | Clindamycin                                        | 14                  |
| 48  | Peripheral vascular disease | 1   | Cat         | Deep muscle abscess  | 4            | Abscess drainage | Carbapenem                     | Amoxicillin clavulanate + ciprofloxacin           | 14 + 14              |
| 78  | None          | 0   | Cat         | Synovial (knee) fluid | 9            | Arthrotomies and joint debridement | Ceftriaxone | Doxycycline                        | 42 + indefinite     |
| 92  | Dementia      | 1   | Cat         | Blood and synovial (shoulder and knee) fluid | 7*          | Arthrotomies and joint debridement | Ceftriaxone | Amoxicillin                        | 28 + 180            |
| 35  | None          | 0   | Dog         | Skin                 | 0            | None            | n/r                            | n/r                                                 | n/r                 |

aa = age-adjusted, CCI = combined comorbidity index, COPD = chronic obstructive pulmonary disease, IV = intravenous, n/a = not available, n/r = not reported, Skin = incision and drainage; Required ICU.

Species of animal bite.

All skin surgeries were incision and drainage procedures.

Skin scratch.
| Age | Comorbidities | CCI | Location of Infection | Hospital Days | ICU | Death | Required Surgery | IV Antibiotic Regimen | Oral Antibiotic Regimen | Antibiotic Duration |
|-----|---------------|-----|-----------------------|---------------|-----|-------|------------------|-----------------------|------------------------|---------------------|
| 66  | Multiple myeloma, COPD | 3   | Blood                | 6             | 0   | No    | None             | Piperacillin tazobactam | Amoxicillin           | 4 + 14               |
| 73  | Metastatic ovarian cancer, pulmonary embolism | 7   | Blood                | 5             | 0   | Yes   | None             | Piperacillin tazobactam | No oral antibiotics   | 3                   |
| 54  | Cirrhosis (MELD 33) | 3   | Blood                | 7             | 7   | Yes   | None             | Ampicillin sulbactam    | No oral antibiotics   | 7                   |
| 64  | Myelodysplastic syndrome, Burkitt lymphoma | 4   | Blood                | 8             | 0   | No    | None             | Ceftriaxone            | No oral antibiotics   | 14                  |
| 55  | Subdural hematoma | 1   | Blood/subdural empyema | 17            | 13  | No    | Subdural drainage | Ampicillin             | No oral antibiotics   | 14                  |
| 36  | ESRD, SLE, cerebrovascular disease | 4   | Blood/peritoneal dialysis fluid | 15            | 8   | No    | Peritoneal catheter removal | Ciprofloxacin          | Ciprofloxacin         | 7 + 14               |
| 81  | Melanoma | 2   | Blood                | n/r           | n/r | n/r   | n/r              | n/r                   | n/r                   | n/r                 |
| 41  | COPD | 1   | Respiratory          | 8             | 6   | No    | None             | Vancomycin             | Moxifloxacin           | 5 + 10               |
| 73  | COPD | 1   | Respiratory          | 5             | 0   | No    | None             | Vancomycin + cefepime  | Moxifloxacin           | 2 + 14               |
| 54  | Subarachnoid hemorrhage | 1   | Respiratory          | 180           | 40  | No    | None             | Vancomycin + carbapenem | No oral antibiotics   | 14                  |
| 68  | Myelodysplastic syndrome, COPD | 3   | Respiratory          | 16            | 16  | Yes   | None             | No IV antibiotics      | Amoxicillin in clavulanate | 14                  |
| 64  | Cirrhosis (MELD 29) | 3   | Synovial (knee) fluid | 8             | 7   | Yes   | Arthrotomies and joint debridement | Meropenem + cefazolin | No oral antibiotics   | 8                   |
| 51  | Diabetes with ESRD | 2   | Deep muscle abscess  | 4             | 0   | No    | Abscess drainage | Vancomycin             | No oral antibiotics   | 2                   |
| 56  | Diabetes | 1   | Deep muscle abscess  | 7             | 0   | No    | Abscess drainage | Vancomycin + cefepime  | Doxycycline           | 4 + 56               |
| 44  | Pulmonary embolism | 1   | Peritoneal fluid     | 6             | 0   | No    | Pancreatic cyst drainage | No IV antibiotics | Sulfamethoxazole trimethoprim | 14                  |
| 87  | None | 0   | Skin                 | 3             | 0   | No    | Skin ID         | No IV antibiotics      | Amoxicillin in clavulanate | 14                  |
| 83  | None | 0   | Skin                 | 0             | 0   | No    | None           | No IV antibiotics      | Sulfamethoxazole trimethoprim | 10                  |
| 65  | None | 0   | Skin                 | 0             | 0   | No    | None           | No IV antibiotics      | Cephalexin            | 10                  |
| 57  | None | 0   | n/a                  | 0             | 0   | No    | None           | n/a                   | n/a                  | n/a                 |

CCI = combined comorbidity index, COPD = chronic obstructive pulmonary disease, ESRD = end-stage renal disease, ID = incision and drainage, IV = intravenous, MELD = model for end-stage liver disease, n/a = not available, n/r = not reported, SLE = systemic lupus erythematosus.
care, had longer LOSs, and had a higher mortality rate than patients with non-bite-associated infections. In our study, the mortality rate for patients with *P. multocida* infection in the absence of an animal bite was 4 of 19 patients (21%) and all of these patients appeared to have an underlying disease that could lead to being immunocompromised (2 cirrhosis or 2 widespread malignancy). Finally, our study was consistent with previous work in which a high mortality has been reported for patients with *P. multocida* infections and bacteremia, pneumonia, arthritis, or peritonitis.\(^\text{10,20}\)

Based on our data, we conclude that comorbidities are likely to be an important risk factor for development of non-bite *P. multocida* infection. Further, we speculate that the presence of comorbidities may have contributed to poorer outcomes in this group. In contrast, the presence of comorbid conditions, as measured using the CCI, did not appear to influence the clinical outcome in patients presenting with animal bite-associated infections. Malignancies, pulmonary and cerebrovascular diseases were common among patients presenting with bloodstream infection. COPD was associated with most lung infections. Indeed, our data are consistent with several case reports that have described bacteremia occurring predominantly in patients with preexisting liver disease or in immunosuppressed patients.\(^\text{1,2,6,8,9,14,17,19–21}\)

Our data have important implications for primary care and generalist care providers. This is because it is estimated that there are some 70 million dogs and 74 million cats in the United States, and approximately 37% of all households in the United States have a dog, and 30% have a cat.\(^\text{29}\) Although it has been proposed dogs and cats are safe overall, physicians should be particularly attuned to the possibility of Pasteurella multocida infection leading to life-threatening complications in patients with significant co-morbidities and advise against unnecessary pet exposures.\(^\text{30}\) Not unexpectedly, most of the patients presenting with *Pasteurella multocida* infection without an animal bite had contact with pets. In these patients, either a skin tear or a percutaneous catheter was reported as the source of infection.)

Thus, based on our findings, we speculate that an immunocompromised state may predispose to *P. multocida* infection without an animal bite.

The treatment of choice for *P. multocida* infections has typically been with penicillin.\(^\text{1,32}\) However, rare penicillin-resistant *P. multocida* strains in human infections have been described.\(^\text{33,34}\) In these cases, second- and third-generation cephalosporins, fluoroquinolones, and tetracyclines are recommended for treatment.\(^\text{1}\) Antibiotic resistance cannot be determined for our study because susceptibility testing other than beta lactamase testing has not been performed in our institution except upon request. In addition, beta lactamase data were not available for 18% of patients. Although this study was able to capture detailed clinical data on an extremely large cohort, we recognize several limitations. First, it was retrospective and follow-up information is unavailable after hospital discharge. Thus, it could potentially be subject to recall bias, and it is possible that we could have missed patients with *P. multocida* infection in our databases. However, we doubt this possibility because we used 2 different methods to identify patients. Further, even if such a bias was present, we do not believe that it would alter the conclusions of our study. Additionally, the study was performed at a single center and reflected patients in South Carolina and the greater Charleston area, which could limit its generalizability to the United States. Further, the single-center nature of the study could create a bias related to either a high or low number of pet owners in our clinical catchment area. We tend to doubt this potential bias since to the best of our knowledge, the demographics of pet owners in South Carolina and Charleston reflect those of the entire United States.\(^\text{29}\)

In conclusion, compared with animal bite-associated *P. multocida* infections, non-animal-bite-associated infections were found primarily in patients with severe comorbidities and immunodeficient states, were often associated with systemic infections, the need for ICU management, longer hospital LOS, and an increased mortality rate. In particular, the high mortality rate in patients with non-animal bite *P. multocida* infection suggests that aggressive treatment approaches are warranted in immunocompromised patients.

REFERENCES

1. Zurlo JJ. Pasteurella species. 6th ed. New York: Churchill Livingstone; 2005.
2. Kimura R, Hayashi Y, Takeuchi T, et al. Pasteurella multocida septicemia caused by close contact with a domestic cat: case report and literature review. *J Infect Chemother.* 2004;10:250–252.
3. Owen CR, Boker EO, Bell JF, et al. Pasteurella multocida in animals’ mouths. *Rocky Mt Med J.* 1968;65:45–46.
4. Francis DP, Holmes MA, Brandon G. Pasteurella multocida. Infections after domestic animal bites and scratches. *JAMA.* 1975;233:42–45.
5. Hubbert WT, Rosen MN. Pasteurella multocida infection in man unrelated to animal bite. *Am J Public Health Nations Health.* 1970;60:
6. Wilson BA, Ho M. Pasteurella multocida: from zoonosis to cellular microbiology. *Clin Microbiol Rev.* 2013;26:631–655.
7. Breen D, Schonell M, Au T, et al. Pasteurella multocida: a case report of bacteremic pneumonia and 10-year laboratory review. *Pathology.* 2000;32:152–153.
8. Weber DJ, Wolfson JS, Swartz MN, et al. Pasteurella multocida infections. Report of 34 cases and review of the literature. *Medicine.* 1984;63:133–154.
9. Milder JE, Hall NK, Finley RA. Pasteurella multocida pneumonia and bacteremia. *Southern Med J.* 1977;70:1123–1124.
10. Klein NC, Cunha BA. Pasteurella multocida pneumonia. *Semin Respir Infect.* 1997;12:54–56.
11. Kofleridis DP, Christofaki M, Mantadakis E, et al. Bacteremic community-acquired pneumonia due to Pasteurella multocida. *Int J Infect Dis.* 2009;13:e81–83.
12. Baillot R, Voisine P, Cote LM, et al. Deep sternal wound infection due to Pasteurella multocida: the first case report and review of literature. *Infection.* 2011;39:575–578.
13. Charalampopoulos A, Apostolakis M, Tsiodra P. *Pasteurella multocida* pneumonia in an elderly non-immunocompromised man with a leg ulcer and exposure to cats. *Eur J Int Med.* 2006;17:380.
14. Harris PJ, Osswold MB. *Pasteurella multocida* epiglottitis: a review and report of a new case with associated chronic lymphocytic leukemia. *Eur Respir J.* 2010;89:4.
15. Heydemann J, Heydemann JS, Antony S. Acute infection of a total knee arthroplasty caused by *Pasteurella multocida*: a case report and a comprehensive review of the literature in the last 10 years. *Int J Infect Dis.* 2010;14(Suppl 3):e242–e245.
16. Nagata H, Yamada S, Uramaru K, et al. Acute cholecystitis with bacteremia caused by Pasteurella multocida. *Surg Infect.* 2014;15:72–74.

17. Samarkos M, Fanourgiakis P, Nemtzas I, et al. Pasteurella multocida bacteremia, spontaneous bacterial peritonitis and septic arthritis in a cirrhotic patient. *Hippokratia.* 2010;14:1.

18. Sol PM, van de Kar NC, Schreuder MF. Cat induced Pasteurella multocida peritonitis in peritoneal dialysis: a case report and review of the literature. *Int J Hyg Environ Health.* 2013;216:211–213.

19. Tseng HK, Su SC, Liu CP, et al. Pasteurella multocida bacteremia due to non-bite animal exposure in cirrhotic patients: report of two cases. *J Microbiol Immunol Infect.* 2001;34:293–296.

20. Raffi F, Barrier J, Baron D, et al. Pasteurella multocida bacteremia: report of thirteen cases over twelve years and review of the literature. *Scand J Infect Dis.* 1987;19:385–393.

21. Yokose N, Dan K. Pasteurella multocida sepsis, due to a scratch from a pet cat, in a post-chemotherapy neutropenic patient with non-Hodgkin lymphoma. *Int J Hematol.* 2007;85:146–148.

22. Oehler RL, Velez AP, Mizrachi M, et al. Bite-related and septic syndromes caused by cats and dogs. *Lancet Infect Dis.* 2009;9:439–447.

23. Talan DA, Citron DM, Abrahamian FM, et al. Bacteriologic analysis of infected dog and cat bites. Emergency Medicine Animal Bite Infection Study Group. *N Engl J Med.* 1999;340:85–92.

24. Fleisher GR. The management of bite wounds. *N Engl J Med.* 1999;340:136–140.

25. Charlson ME, Pompei P, Ales KL, et al. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis.* 1987;40:373–383.

26. Charlson M, Szatrowski TP, Peterson J, et al. Validation of a combined comorbidity index. *J Clin Epidemiol.* 1994;47:1245–1251.

27. Elixhauser A, Steiner C, Harris DR, et al. Comorbidity measures for use with administrative data. *Med Care.* 1998;36:8–27.

28. Sharabiani MT, Aylin P, Bottle A. Systematic review of comorbidity indices for administrative data. *Med Care.* 2012;50:1109–1118.

29. Association AVM. U.S. Pet Ownership Statistics. 2012; https://www.avma.org/KB/Resources/Statistics/Pages/Market-research-statistics-US-pet-ownership.aspx. Accessed 1/20/2015, 2015.

30. Olshtain-Pops K, Yinnon AM. Pasteurella multocida sepsis—should immunocompromised patients give up their pets? *Israel Med Assoc J.* 2008;10:648–649.

31. Azar AE, Ballas ZK. Evaluation of the adult with suspected immunodeficiency. *Am J Med.* 2007;120:764–768.

32. Spagnuolo PJ, Friedman RI. Penicillin sensitivity of invasive and non-invasive Pasteurella multocida. *J Antimicrob Chemother.* 1979;5:324–325.

33. Lion C, Lozniewski A, Rosner V, et al. Lung abscess due to beta-lactamase-producing Pasteurella multocida. *Clin Infect Dis.* 1999;29:1345–1346.

34. Naas T, Benauoudia F, Lebrun L, et al. Molecular identification of TEM-1 beta-lactamase in a Pasteurella multocida isolate of human origin. *Eur J Clin Microbiol.* 2001;20:210–213.