Nineteen Cases of Plague in Arizona

A Spectrum Including Ecthyma Gangrenosum Due to Plague and Plague in Pregnancy

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We review the cases of 19 successfully treated plague patients, with emphasis on the clinical and epidemiologic features of the disease. Proper staining and culturing of bubo aspirates; prompt institution of streptomycin, chloramphenicol or tetracycline therapy in presumptive cases, and supportive care are the crucial factors in the treatment of plague. This disease should be considered in patients in a toxic condition who have lymphadenitis, pneumonia or septic shock and who have been in endemic areas within the past ten days.

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Clinicians should be aware that the same plague that devastated medieval Europe is endemic in the western United States, and at least nine cases of the disease have appeared in other parts of the country as a result of travel of exposed persons from endemic areas.[1-3] Because plague has a wide range of clinical presentations and can cause death within hours of the initial visit to a physician, it is essential to include plague in the differential diagnosis of a wide variety of febrile illnesses and to be sufficiently familiar with and equipped for diagnostic procedures to ensure rapid diagnosis. Three of the nine patients (33%) died in nonendemic areas of the United States compared with a case-fatality ratio of 18% in nontravelers.[2]

The purpose of the report is to make physicians aware of this ancient but still active disease. The death rate is high if diagnosis and appropriate therapy are delayed. From 1966 to May 1983, all 19 plague cases diagnosed among Navajos living on the western Navajo Reservation were successfully treated (a case-fatality rate of 0% compared with the national rate of 14%). We report the clinical features of the 19 cases (Table 1) and describe three of the case histories that show the diversity of the clinical presentations of plague.

Cases were ascertained by reviewing cases reported to the Centers for Disease Control and those admitted to Navajo Area Indian Health Service hospitals. Cases of patients who died out of hospital may not have been ascertained because postmortem blood cultures are only rarely done when Navajos die out of hospital. Case ascertainment of survivors is probably complete because plague is such an unusual and serious disease that physicians are very likely to report it. We considered cases to be confirmed only if *Yersinia pestis* was isolated from clinical specimens or if there was a fourfold or greater rise in passive hemagglutination titer of plague antibody.

Report of Selected Cases

Case 4

A 31-year-old woman in her ninth month of pregnancy was referred to Tuba City (Arizona) Hospital from an outlying clinic in early May 1975 with a one-day history of fever to 40°C (104°F) and severe headache. Plague was suspected when a Giemsa stain of an aspirate of her enlarged, exquisitely tender right axillary lymph nodes showed bipolar rods suggestive of *Y pestis*; streptomycin therapy was begun two hours after admission. When a fetal tachycardia of 200 beats per minute suggested fetal distress, labor was induced with administration of oxytocin. Two and a half hours after antibiotic therapy was started, a male infant with Apgars of 9 and 10 at one and five minutes, respectively, was delivered

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ABBREVIATIONS USED IN TEXT

FA = fluorescent antibody
P_{CO_2} = partial carbon dioxide pressure
P_{O_2} = partial oxygen pressure

without complication and was treated empirically with streptomycin. The maternal lymph node and blood cultures were confirmed as containing *Y pestis* but a cord blood culture was negative for plague. Chloramphenicol was added to the streptomycin treatment of the mother for five days postpartum and she was treated with tetracycline as the sole antibiotic from the fifth to the tenth day of treatment. A mild disseminated intravascular coagulation—manifested by decreased platelets, prolonged partial thromboplastin time and elevated fibrin-degradation products—spontaneously corrected with antibiotic therapy alone. The patient became afebrile on the seventh day of illness, and the lymphadenopathy resolved on the eighth day of illness. Two days later her 2½-year-old daughter was also admitted with a two-day history of fever to 40.2°C (104.°F), headache, vomiting and cough. Plague was diagnosed by culture of an aspirate of her exquisitely tender right axillary lymph nodes, and she was treated with streptomycin. All three patients were well at discharge nine days after the mother's admission. The baby's hemagglutination titer remained negative for plague antibody.

Case 7

A 15-year-old severely ill boy was admitted the end of February 1976 with a three-day history of high fever and severe pain in the axillae. He had skinned a dead rabbit two days before the onset of illness. On admission bilateral, exquisitely tender, enlarged axillary lymph nodes were noted. Wayson stain of a specimen of aspirate showed bipolar rods suggestive of *Y pestis*. Blood cultures and bubo aspirate cultures were all positive for *Y pestis*.

The patient was placed in respiratory isolation and was treated with streptomycin initially. Chloramphenicol was added to the regimen the next day. Six hours after admission the patient began hallucinating, hyperventilating and coughing frothy white sputum. Cerebrospinal fluid was clear with no cells and no bacteria on Gram's stain, and the culture was subsequently negative. A chest radiograph taken ten hours after admission showed a symmetric, mixed pulmonary pattern of both reticular and alveolar densities radiating from the hila bilaterally, borderline cardiomegaly and Kerley B lines (Figure 1.) A sputum specimen contained bipolar rods compatible with *Y pestis* on Wayson stain and was positive for fluorescent antibody (FA), but the organism did not grow on culture. Blood gas determinations done with the patient breathing room air showed a pH of 7.05, a partial oxygen pressure (P_{O_2}) of 36 mm of mercury and a partial carbon

TABLE 1.—*Clinical and Demographic Features of 19 Patients With Plague*

Type
- 15/19 Bubonic (*Yersinia pestis* infection with lymphadenitis; 4/15 with secondary pneumonia)
- 4/19 Septicemic with no adenopathy (1/4 with secondary pneumonia)

Month of Occurrence (# of cases)
- January (2), February (1), April (2), May (7), June (2), July (3), August (1), November (1)

Ages
- Range 2½-78 years
- Average age 25.0 years
- 12/19 16 or younger (pediatric cases)
- 7/19 17 or older (adult cases)

Sex
- 13/19 ♀; 6/19 ♂

Duration of Hospital Stay
- Range 6-28 days (all patients were admitted to hospital)
- Mean 13.8 days

Headache
- 10/19 yes; 6/19 no; 2/19 unknown; 1/19 seizure

Cough
- 3/19 yes; 15/19 no; 1/19 unknown

Skin Manifestations
- 3/19 (1 with ecthyma gangrenosum, 1 with petechiae and 1 with massive cutaneous edema)

Adenitis
- 4/19 no
- 15/19 yes
- 10/15 axillary; 1/15 cervical; 3/15 inguinal; 1/15 femoral

Admission Temperature
- Range 37°C (98.6°F)-40.9°C (105.6°F), only 1 less than 38.3°C (101°F)
- Average 39.4°C (102.9°F)

Admission Leukocyte Count (per μl)
- Range 8,700-48,200
- Average 18,763 (only 2 less than 10,000)

Lowest Platelets (per μl)
- Range 26,000-318,000
- (normal 200,000-350,000)

Sputum Culture
- 1 Positive culture
- 1 Positive Wayson smear and negative culture of specimen taken after 12 h therapy

Bubo Culture
- 14/15 Positive; 1/15 negative (positive FA and positive convalescent PHA 1/512)

Blood Culture
- 15/19 Positive; 3/19 negative; 1/19 not done

Chest X-ray Film
- 12/19 Normal
- 2/19 Definite secondary plague pneumonia (sputum culture or FA test positive for *Y pestis*)
- 3/19 Pneumonia probably due to plague but not confirmed on smear or culture
- 1/19 Minimal pneumonia not thought to be related to plague
- 1/19 Pleural effusion

Prothrombin Time
- Not prolonged in 12 patients tested

Partial Thromboplastin Time
- Prolonged in 3 of 11 patients tested

PHA Titer to Fraction 1 of *Yersinia pestis*
- 2/19 not done; 1/19 negative; 16/19 positive; range 1:4-1:4,096

Antibiotic Treatment
- 15/19 Streptomycin; 8/19 chloramphenicol; 15/19 tetracycline; 3/19 gentamicin sulfate; 1/19 never received recommended antibiotic treatment but recovered.

FA = fluorescent antibody; PHA = passive hemagglutination antibody titer

dioxide pressure (P_{CO_2}) of 19 mm of mercury. Septic shock and adult respiratory distress syndrome developed (Figure 2) as a result of secondary pneumonic plague.

These complications resolved with the administration of high-flow oxygen by mask, dopamine hydrochloride intravenously, methylprednisolone and sodium bicarbonate. He became afebrile on the 24th day of illness and persistent tenderness of axillary nodes gradually resolved without surgical intervention. His chest radiograph became normal on the 15th day of illness. Results of coagulation studies consistent with disseminated intravascular coagulation (see Table 1) were corrected by the end of his course of therapy. Six of the patient's relatives and 17 hospital contacts were located and treated prophylactically with tetracycline because they were at risk for primary pneumonic plague developing. None became ill with plague.

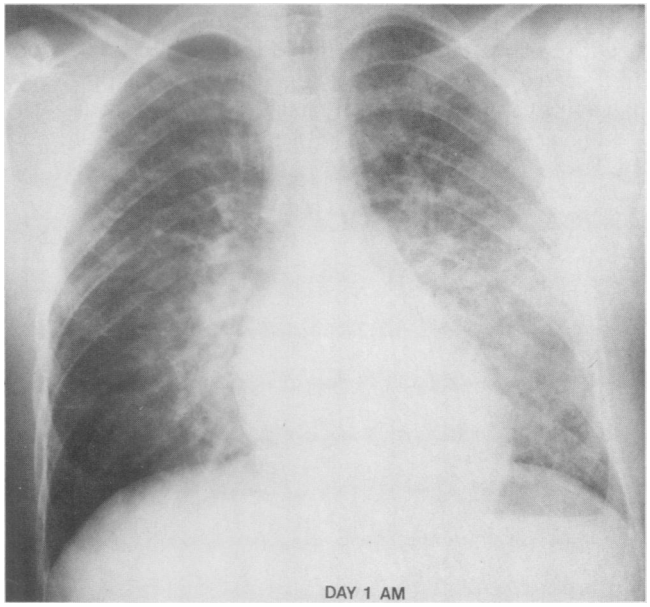

Figure 1.—Erect posteroanterior chest radiograph of patient in case 7 on the third day of illness, ten hours after hospital admission. Symmetric reticular and alveolar densities radiate from the hila bilaterally. The heart is at the upper limits of normal in size. Kerley B lines are very prominent in the lateral costophrenic angles. The radiographic findings are compatible with cardiac decompensation, pulmonary edema and symmetric pulmonic infiltrates of pneumonia.

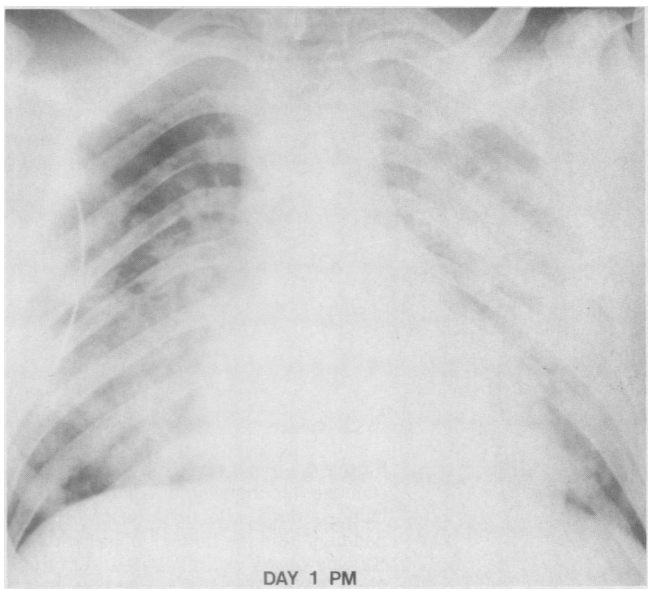

Figure 2.—An anteroposterior chest radiograph of the patient in case 7 taken on the fourth day of illness, 20 hours after admission, shows more coalescent densities bilaterally, which appear more like pneumonia than pulmonary edema.

Case 12

The patient, a 72-year-old woman, was admitted with a one-day history of vomiting, weakness and fever. She had no adenopathy or skin lesions. The findings on her admission chest radiograph were equivocal, and she was initially treated for pneumonia with a course of cefazolin sodium. On the third day of illness, she became short of breath. A repeat chest radiograph showed pronounced consolidation in both lower lobes. Three pustular lesions also developed in the patient: one on the left posterior thigh, one on the right pubis (Figure 3) and one on the right buttock (Figure 4). At this time, her admission blood culture was reported to be growing Gram-positive rods in chains that could not be identified. Because she remained severely ill, plague was suspected and she was treated with a regimen of chloramphenicol. She was not coughing and was, therefore, not isolated. She became hypotensive (blood pressure 80/60 mm of mercury) and obtunded, and blood gas measurements done while the patient was receiving three liters per minute of oxygen by mask showed a pH of 7.41 and a P_{O_2} of 53 and P_{CO_2} of 21 mm of mercury. The lowest platelet count was 46,000 per μl and livedo of the legs developed, but prothrombin and partial thromboplastin times remained normal. Fluid therapy was monitored with a Swan-Ganz catheter, blood pressure was supported with a dopamine drip and her P_{O_2} was maintained at between 55 and 80 mm of mercury by mask. Gentamicin sulfate was added to the treatment regimen on the fifth day of illness because the patient's condition was not improving and because an etiologic organism had not been identified. On the eighth day, when the patient had improved clinically, cultures of specimens of blood and the pustular skin lesion (taken on day 3) were confirmed to contain *Y pestis* by fluorescent antibody tests.

Administration of chloramphenicol and gentamicin was continued until the 14th day of illness, when the chest radiograph showed clearing, the skin lesions were fading and the platelet count had returned to normal. On the 18th day of illness, her temperature rose to 38.3°C (101°F). Cultures of two blood specimens obtained at that time were negative and no explanation for her fever was found. Tetracycline therapy was added for an additional ten days. She was discharged on the 25th day of illness and has remained well.

Despite the lack of isolation procedures, no secondary cases of plague developed in the staff or visitors. A total of 22 hospital staff members were treated prophylactically with tetracycline (or trimethoprim/sulfamethoxazole if they were pregnant) after the diagnosis of plague was confirmed.

Discussion

Clinical Features

Exquisitely tender lymph nodes are the most typical diagnostic physical features of the cases discussed in this series. Aspiration of affected lymph nodes, culture on blood agar and

staining of the aspirates by Wayson or Giemsa and Gram's methods and by specific fluorescent antibody are the crucial preliminary steps in making a presumptive and, eventually, a confirmatory diagnosis. The FA test requires other qualitative tests including plague susceptibility testing for final confirmation of *Y pestis*. Blood cultures should be done in every suspected case. If pulmonary infection is suspected, sputum should be induced or, in patients unable to cough, tracheal aspiration should be done. The first case of pneumonic plague described here (case 7) showed *Yersinia*-like organisms on sputum smear but a negative sputum culture, probably because antibiotic therapy was started ten hours before the sputum specimen was collected. In such circumstances, slides should be prepared for FA tests that allow a presumptive identification of *Y pestis*. Because *Y pestis* is slow growing even at the optimal temperature of 28°C,[4] FA examination of the sputum will also provide an earlier presumptive test for *Y pestis*.

The thrombocytopenia noted in 9 of the 19 patients and the ecchymoses noted in one patient have been previously described in association with plague.[5] These disorders of coagulation resolved with specific antibiotic therapy alone.

The hypoxia, hypotension and acidosis noted in case 7 responded to the administration of oxygen, dopamine, steroids and bicarbonate. The clinical picture was that of endotoxic shock that occurred soon after streptomycin therapy was begun, possibly as a result of rapid lysis of *Y pestis* by the drug, causing release of endotoxin. Patient 12 had primary septicemic plague, a frequently fatal form of the disease that is difficult to diagnose because the typical buboes are not

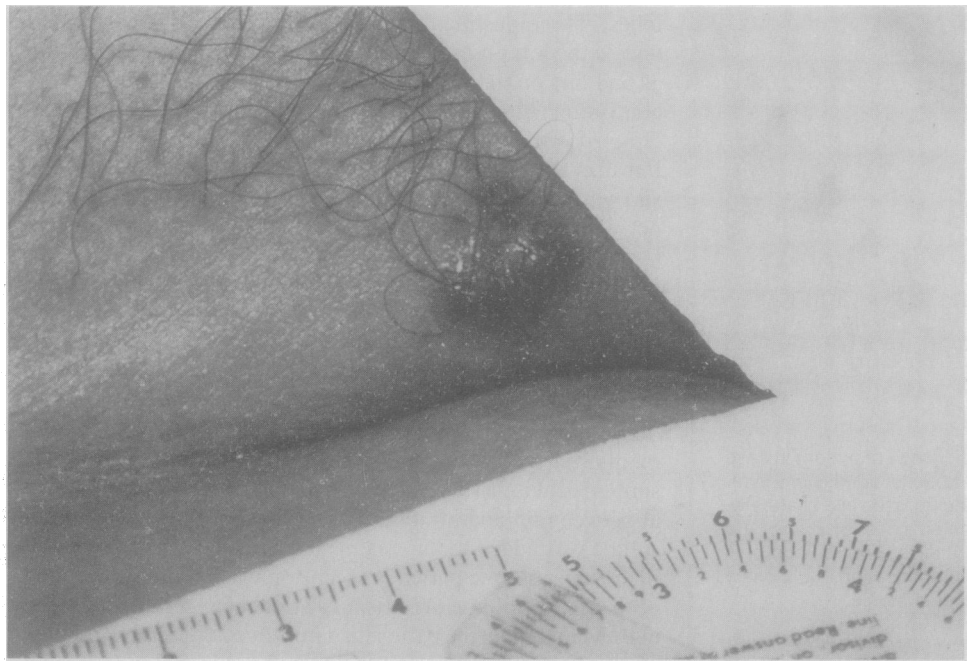

Figure 3.—Confluent hemorrhagic pustules on a violaceous base, an intermediate stage of ecthyma gangrenosum, developed on the right mons pubis of patient 12. The right thigh is below. Scale is in centimeters.

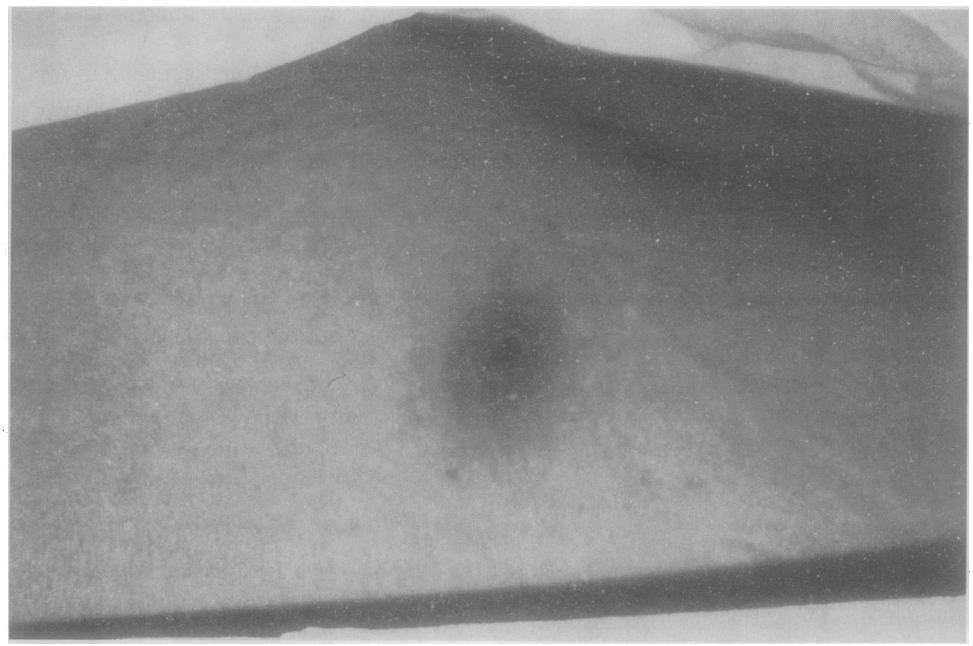

Figure 4.—Final stage of ecthyma gangrenosum, consisting of concentric violaceous rings with an area of central necrosis from the buttock of patient 12. *Yersinia pestis* was aspirated from this 2-cm lesion. Lesions of ecthyma gangrenosum associated with *Pseudomonas* septicemia are also commonly found in the anogenital region and thighs.

present.[6] Probable secondary pneumonic plague and skin lesions characteristic of ecthyma gangrenosum (Figures 3 and 4) developed in this patient. Ecthyma gangrenosum is most frequently associated with *Pseudomonas* infections but can be associated rarely with other Gram-negative infections.[7] Although ecthyma gangrenosum has not been recognized as a complication of *Y pestis* infections, vesicular and pustular skin lesions have been described in some cases of plague.[5] Two cases of "plague carbuncles," which resembled the malignant pustules of anthrax, have been reported.[8] A Vietnamese patient with a fatal case of bubonic plague had lesions similar to those present in our patient. An antemortem skin biopsy specimen of one lesion showed focal epidermal necrosis with subepidermal hemorrhage and fibrin thrombi in the blood vessels. Giemsa stain showed bacillary bacteria embedded in the thrombus but the lesion was not cultured.[5] Specimens from two of the lesions in case 12 were cultured and grew *Y pestis*; this suggests that they were the result of septicemic seeding of the organism in the dermis and epidermis. Biopsies of these lesions were not done.

Case 12 was also unusual in that the organism was initially reported by the laboratory as a Gram-positive rod in chains but was confirmed as *Y pestis* by FA tests six days later. The blood culture from a fatal case of plague in Texas was first reported as growing Gram-positive cocci in pairs.[9] Gram-variable staining may explain these results or they may be due to laboratory error. The index of suspicion for plague was sufficiently high for the patient in case 12 to be treated with chloramphenicol, a treatment that was lifesaving. Isolation of patients with plague is recommended to prevent transmission to medical personnel by aerosol should plague pneumonia develop (see p 646). Although the patient in case 12 was not isolated immediately, she did not cough and no secondary cases developed. It is advisable to obtain a history of possible plague exposure in any severely ill patient who has an unidentifiable organism growing on blood, sputum or bubo culture. If a possibility of exposure to plague exists, appropriate antibiotic therapy and isolation procedures should be initiated until a diagnosis is confirmed.

The patients in cases 7 and 12 showed problems of continued pyrexia after an apparent appropriate response to specific antibiotic therapy. Numerous causes of continued pyrexia must be considered in such circumstances, including unlikely possibilities that a drug-resistant *Y pestis* strain has developed or that the fever is drug-induced. If nosocomial infections are ruled out, such fever may be due to necrosis within a lymph node.[5] Buboes may point and drain spontaneously or require incision and drainage because of pronounced necrosis. Transmission of infection to contacts from such material has not been reported, but draining bubo material should be properly disposed of to prevent this possibility.

Streptomycin is bactericidal for *Y pestis* and is the drug of choice for treatment of plague patients. Chloramphenicol, gentamicin and tetracycline are also effective antibiotics and may be given intravenously in hypotensive patients in whom mobilization of streptomycin given intramuscularly is compromised. Oral tetracycline can be used to complete a full therapeutic ten-day course of therapy after streptomycin, intravenous chloramphenicol or gentamicin has been given for five days in the clinic or hospital. Such a change minimizes the risk of renal and vestibular damage from streptomycin. To our knowledge, no animal studies nor sensitivity testing has been done for sulfamethoxazole-trimethoprim or doxycycline and they are not recommended for treatment because adequate clinical trials have not been done.[10] Although gentamicin has been used successfully as the sole antibiotic in treating plague patients, it is not recommended as a first-line drug because streptomycin is more effective than gentamicin in treating mice experimentally infected with plague.[10]

We attribute our success in treating cases of plague to a high index of suspicion, the use of simple and rapid plague-specific diagnostic tests, promptly instituting recommended antibiotics and providing adequate supportive care. Only one patient did not receive recommended antibiotics—a child with an atypical presentation and clinical course (to be described in a separate case report).

Obstetric Management

In the preantimicrobial era, plague during pregnancy regularly resulted in abortion, and the aborted tissues were occasionally infected with the plague bacillus.[4] In 1903 Jennings reported 10,000 cases of plague, 14 of which occurred during pregnancy.[11] Four of the mothers survived, but spontaneous abortions or stillbirths occurred in 13 of the patients, including the four survivors. One of the 14 patients was near her expected date of delivery. The child was born apparently well, but the mother died of postpartum hemorrhage. Ten hours after the birth, lymphadenopathy was noted in the infant's groins and axillae and it died one day later.[11]

Information is sparse on plague during pregnancy since antimicrobial agents became available. In 1975 and 1976, plague was recognized during pregnancy in three patients; two women, aged 28 and 39, were in their fifth month of gestation.[12,13] Our patient (case 4) was at term when she was infected. Of the patients infected during the second trimester of gestation, one was successfully treated with streptomycin[12] and one received a combination of streptomycin and tetracycline.[13] After normal gestation periods, healthy infants were delivered from each. Because a fetus or infant may be exposed to plague either transplacentally[4] or through contact with maternal blood during the birth process, induction of labor or cesarean section should be considered when fetal distress is noted at 36 or more weeks' gestation in infected mothers. A newborn should be treated empirically.

Radiologic Features

Case 7 shows the need to do an admission chest radiograph and to place all cases of possible plague in respiratory isolation; clinical evidence of respiratory involvement in this patient consisted of coughing, which began six hours after admission. The radiographic appearance of secondary plague pneumonia usually is bilateral alveolar infiltrates.[14] Three of the patients with secondary pneumonic plague described in this report also had patchy areas of parenchymal consolidation on the initial chest radiographs; these areas became more confluent on repeat radiographs 12 or 24 hours later. In case 7, widespread interstitial and patchy alveolar disease characteristic of severe pulmonary edema was more prominent. Subsequent radiographs showed sequential resolution of the extensive patchy air space consolidation, with complete clearing of the infiltrates after 13 days of therapy.

Although patchy pulmonic infiltrates on a chest radio-

graph of a patient who is severely ill can suggest the diagnosis of plague in the proper epidemiologic setting, radiographic findings are not etiologically suggestive but rather provide a valuable index for following therapeutic response.

Epidemiologic Features

Plague remains endemic in the Southwest by epizootics that occur in small rodents.[15,16] From 1965 through June 1983, 197 cases of plague were reported to the Centers for Disease Control from the United States, and 19 of those (9.6%) were from the western Navajo Reservation. A case-fatality rate of 14% occurred nationwide,[17] but there were no deaths in the 19 cases in this report. The mean annual incidence rates per 100,000 population in Arizona, New Mexico and Utah are 1.4 for Indians, 0.1 for non-Indians[17] and 2.6 for the western Navajo Reservation. The Navajo rural life-style brings people into contact with animals or fleas bearing *Y pestis* more frequently than that of other ethnic groups.[18] In 1966 and 1967, 6.8% of 266 dogs in the Tuba City area had titers positive for plague antibody.[19] Although dogs usually do not become ill when infected with plague, they may carry plague-bearing fleas if they have frequent contact with rodents in which plague is endemic.[19] In contrast, rodents usually die when infected. In the Tuba City area, four different species of rodents and a rabbit were positive by culture or FA. Since 1967 prairie-dog colonies on the Navajo Reservation have been mapped and periodically surveyed for "die offs" (high death rates) to detect the presence of *Y pestis*. In this manner resident dogs and prairie-dog colonies have been used as sentinels of human disease on the Navajo Reservation.

Intensive educational programs were begun in the areas where plague was identified. Community residents were assisted in dusting their dogs and cats with flea powder, advised to avoid handling dead rodents and instructed to report to a clinic immediately if signs or symptoms of plague developed.

Four of our patients apparently contracted plague while dissecting rabbits, presumably by direct contact of broken skin with infected rabbit tissues or blood. Most cases of plague that occur in the winter months are caused by direct contact with infected animal tissues.[15] The incidence of human plague is higher in the summer months because the fleas on the animals become more active and the avenues for human contact more frequent.[15] Buboes occurring on the lower torso, primarily in the groin, are generally considered to result from flea bite. Only rarely is a victim aware of flea bites or the precise source of an offending flea.

The risk of person-to-person transmission is not known but is presumed to be low because the last such transmission in the United States was reported in 1924.[20] However, strict isolation is recommended for the first 48 hours of antibiotic therapy for patients with septicemia and bubonic plague and for 96 hours for those with pneumonic plague to minimize the risk to hospital staff. Plague pneumonia developed in five of our patients (26%), compared with a national rate of 23% since 1975.[21] When plague pneumonia develops before a patient is isolated, tetracycline is the preferred prophylactic drug for adult contacts.[10] Based on experience of treating plague in Vietnam, trimethoprim/sulfamethoxazole is recommended for children younger than 8 years and for pregnant women exposed to pneumonic plague.[10] In the United States in the four years from 1975 to 1979, 16 cases of plague pneumonia were diagnosed, with the result that prophylactic therapy was given to more than 1,400 contacts with no evidence of secondary spread.[21] Prophylaxis is not indicated for contacts of nonpneumonic plague cases but community associates should be kept under surveillance because of the possibility of zoonotic exposures to the same source as the index case.[21] Such a situation occurred when plague developed in the daughter of the patient in case 4.

Conclusion and Summary

These 19 cases of plague illustrate the effectiveness of prompt antibiotic therapy for bubonic, secondary pneumonic and septicemic plague on the basis of a tentative diagnosis by Wayson or Giemsa stain of sputum or lymph node aspirate before the diagnosis is confirmed by fluorescent microscopy or culture. Possible human plague cases should be reported through the local and state health agencies to the Plague Branch, Centers for Disease Control, Fort Collins, Colorado. Consultation will facilitate both patient management and appropriate epidemiologic investigation. Plague patients should be strictly isolated for 48 hours until pneumonic plague has been ruled out. Tetracycline is effective for prophylactic treatment of family and hospital contacts who have not followed isolation precedures for pneumonic plague. Usual supportive measures combined with specific antimicrobial therapy appear to be effective in treating endotoxic shock that complicates plague septicemia. A high index of suspicion is crucial in the successful treatment of a case of plague. Physicians practicing in areas where plague is not endemic need to be aware of the possibility that the disease may be imported by patients who have visited the Southwest or other endemic areas.

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