Anthrax

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Synonyms: Woolsorters' Disease, Cumberland Disease, Charbon, Malignant Pustule, Malignant Carbuncle, Milzbrand, Splenic Fever

Etiology
Anthrax results from infection by *Bacillus anthracis*, a spore forming, Gram positive aerobic rod (family Bacillaceae).

Geographic Distribution
Anthrax can be found worldwide; it is particularly common in parts of Africa, Asia and the Middle East. In the United States, foci of infection occur in South Dakota, Nebraska, Mississippi, Arkansas, Texas, Louisiana and California, with smaller areas in other states.

Transmission
In animals, transmission is usually by ingestion. Herbivores usually become infected when they ingest spores on plants in pastures. Outbreaks typically occur in neutral or alkaline calcareous soil and are often associated with heavy rainfall, flood or drought; under optimal levels of moisture, temperature and other conditions, spores in the soil can revert to the vegetative form and grow to infectious levels. Contaminated bone meal and other feed can also spread this disease. Carnivores usually become infected after eating contaminated meat. Vultures and flies may spread anthrax after feeding on carcasses.

In infected animals, large numbers of bacteria are present in the hemorrhagic exudates from the mouth, nose and anus; when they are exposed to oxygen, these bacteria develop endospores and contaminate the soil. Sporulation requires oxygen and does not occur inside a closed carcass; opening an infected carcass for necropsy should be avoided. Anthrax spores can remain viable for decades in the soil or animal products such as dried or processed hides and wool. Spores can also survive for 2 years in water, 10 years in milk and up to 71 years on silk threads. Vegetative organisms are thought to be destroyed within a few days during the decomposition of unopened carcasses.

Humans usually develop the cutaneous form of anthrax after skin contact with infected animal tissues such as hides, wool, bone meal and blood. Biting flies that feed on infected animals or carcasses may also be able to transmit this form. Inhalation anthrax is seen after inhalation of spores from contaminated dust or animal products. Intestinal anthrax results from the ingestion of contaminated meat containing viable spores.

Anthrax has been studied as a weapon by the United States, Iraq, the former Soviet Union and probably other countries.

Disinfection
Anthrax spores are resistant to heat, sunlight, drying and many disinfectants. Spores can be killed with 2% glutaraldehyde formaldehyde or 5% formalin; soaking overnight is recommended. A 10 % NaOH or 5

% formaldehyde solution can be used for stockyards, pens and other equipment. Sterilization is also possible by heating to 121°C for at least 30 min. Blowtorches can be used to disinfect buildings.

Exposed arms and hands can be washed with soap and hot water then immersed for one minute in a disinfectant such as an organic iodine solution or 1 p.p.m. solution of mercuric perchloride. Clothing should be cleaned and boiled.

Infections in Animals

Species Affected
Many species can develop anthrax but susceptibility varies: dogs, rats and chickens are resistant to disease while sheep, cattle and horses are very susceptible. Anthrax has been seen in pigs, mink, cats and dogs fed contaminated meat.

Incubation Period
The incubation period is 1 to 20 days; most infections become apparent after 3 to 7 days. In pigs, the incubation period is usually 1 to 2 weeks.

Clinical Signs
In ruminants, sudden death may be the only sign. Staggering, trembling and dyspnea may be seen in some animals, followed by rapid collapse, terminal convulsions and death. In the acute form, clinical signs are apparent for up to 2 days before death. Fever and excitement may be followed by depression, stupor, disorientation, muscle tremors, dyspnea, abortion, congested mucous membranes and bloody discharges from the nose, mouth and anus. Chronic infections, characterized by subcutaneous edematous swellings, are also seen; the ventral neck, thorax and shoulders are most often involved. This swelling may be widespread.

In horses, common symptoms include fever, chills, anorexia, depression and severe colic with bloody diarrhea. Swellings may be seen in the neck, sternum, lower abdomen and external genitalia. Affected animals usually die within 1 to 3 days but some animals can survive up to a week.

Sudden death may be seen in pigs. Many pigs have mild chronic infections characterized by localized swelling, fever and enlarged lymph nodes, with eventual recovery. Some animals develop progressive swelling of the throat, with dyspnea and difficulty swallowing; these animals may suffocate. Intestinal involvement, with anorexia, vomiting, diarrhea or constipation, is less common. Recovered, asymptomatic animals may have signs of localized infections in the tonsils and cervical lymph nodes at slaughter.

Clinically apparent anthrax in dogs, cats and wild carnivores resembles the disease in pigs.

Communicability
Yes. Large numbers of bacteria are present in the carcass and in bloody discharges from body openings. Tissues including skin and wool can contain spores, which remain viable for long periods of time.

Diagnostic Tests
A presumptive diagnosis is often made by examining blood or other tissues for the characteristic bacteria. Blood clots poorly in anthrax cases and sampling may be done post-mortem. In pigs, bacteremia is rare and a small piece of aseptically collected lymphatic tissue is often used. *Bacillus anthracis* is a large Gram positive rod that may occur singly, in pairs or in chains; endospores are not formed inside the body but may be found under certain culture conditions.

Bacterial culture may be used for diagnosis. *B. anthracis* colonies on blood agar are white or gray, at least 3 mm diameter, nonhemolytic, and have a dry, ground-glass appearance and sometimes tails. Capsules may be demonstrated in mucoid colonies from cultures grown on nutrient agar with 0.7 percent sodium bicarbonate, incubated overnight under CO_2. *B. anthracis* is also susceptible to specific bacteriophages and exhibits a characteristic 'string-of-pearls' formation when grown with penicillin.

Other diagnostic methods include polymerase chain reaction to detect bacterial nucleic acids, immunofluorescence for bacteria in blood or tissues, or a chromatographic assay to detect antigens in the blood. Mouse or guinea pig inoculation is rarely used. Immunoblotting (Western blotting) and enzyme-linked immunosorbent assays (ELISAs) are available; however, serology is rarely used for diagnosis.

Treatment and Vaccination
Antibiotics may be effective if treatment is started early. Vaccines are available for large animals.

Morbidity and Mortality
Clinical infections in ruminants and horses are usually fatal; pigs often recover. In carnivores, mortality is relatively low.

Post-Mortem Lesions
Rigor mortis is usually absent or incomplete and the carcass is typically bloated and decomposes rapidly. Dark, tarry blood may ooze from the body orifices. Edema may be noted, particularly around the throat and neck, in horses. Necropsies should generally be avoided, to prevent contamination of the surrounding area with spores.

If the carcass is opened, signs of septicemia will be evident. The blood is dark, thick and does not clot readily. Edematous, blood-tinged effusions may be seen in the subcutaneous tissues, between skeletal muscles and under the serosa of organs. Hemorrhages, petechia and ecchymoses are often noted in the lymph nodes, abdomen and thorax; hemorrhages and ulcers are also common in the intestinal mucosa. Peritonitis and excessive peritoneal fluid may be seen. The spleen is usually enlarged and has a 'blackberry jam' consistency. The lymph nodes, liver and kidneys may be swollen and congested.

Pigs with chronic anthrax usually have lesions only in the pharyngeal area. The tonsils and cervical lymph nodes are typically enlarged and a mottled salmon to brick-red color on cut surface. The tonsils may be covered by diphtheritic membranes or ulcers. The surrounding area is usually edematous and gelatinous. Some pigs may have a chronic intestinal form, with inflammation and lesions in the mesenteric lymph nodes.

Infections in Humans

Incubation Period
The incubation period in humans is 1 to 7 days; typically, symptoms of inhalation anthrax appear after 2 to 5 days and symptoms of cutaneous anthrax after 2 to 3 days. After accidental aerosol release in the Soviet Union, cases continued to appear for up to 6 weeks.

Clinical Signs
Three forms of disease are seen in humans: cutaneous anthrax, intestinal anthrax and pulmonary anthrax.

Cutaneous anthrax develops after skin infections. This form is characterized by a papular skin lesion, which becomes surrounded by a ring of fluid-filled vesicles. The central papule ulcerates, dries and

develops a depressed, black scab. The skin lesion is usually painless, but is often surrounded by significant edema. Swelling on the face or neck may occlude the airways; lesions on the face or neck can also develop into meningitis. Fever, lymphadenopathy, pus and pain are seen only if secondary infections occur. Most lesions resolve spontaneously but disseminated, fatal infections occur in approximately 20%.

Intestinal anthrax develops after eating contaminated meat. The initial symptoms may be mild and can include malaise, a low fever and mild gastrointestinal symptoms. Severe symptoms then develop acutely and may include high fever, dyspnea, cyanosis, disorientation and other signs of septicemia. Intestinal anthrax rapidly progresses to shock, coma and death.

Pulmonary anthrax occurs after inhaling spores in contaminated dust. Natural infections are mainly seen among workers who handle infected hides, wool and furs. The clinical signs develop gradually and are nonspecific. Symptoms may include fever, tiredness, and malaise; a nonproductive cough and mild chest pain may be present. The symptoms often improve for several hours to 3 days; this period of improvement ends with the acute onset of severe respiratory distress, diaphoresis, stridor and cyanosis, followed by fatal septicemia and shock within one to two days.

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Communicability

Person to person transmission of anthrax is very rare and has been reported only in cases of cutaneous anthrax.

Diagnostic Tests

Anthrax is diagnosed by finding the characteristic organisms in clinical samples or by isolating *B. anthracis*. Blood, fluid samples from skin lesions, aspirates of lymph nodes or spleen, or cerebrospinal fluid (in cases of meningitis) are stained with polychrome methylene blue (M'Fadyean's stain). *B. anthracis* organisms are square-ended, blue-black bacilli surrounded by a pink capsule. Bacteria are not always found in blood cultures during septicemia.

B. anthracis colonies on blood agar are white or gray, at least 3 mm diameter, nonhemolytic, and have a dry, ground-glass appearance and sometimes tails. Capsules may be demonstrated in mucoid colonies from cultures grown on nutrient agar with 0.7 percent sodium bicarbonate, incubated overnight under CO_2. *B. anthracis* is also susceptible to specific bacteriophages and exhibits a characteristic 'string-of-pearls' formation when grown with penicillin. Antibiotic treatment of patients may prevent isolation of the organism.

Treatment and Vaccination

Natural strains of *B. anthracis* are usually susceptible to a variety of antibiotics; most but not all natural strains are susceptible to penicillin. Effective treatment depends on early recognition of the symptoms: treatment for cutaneous anthrax is usually effective but pulmonary and intestinal forms are difficult to recognize and mortality rates are much higher. Pulmonary and intestinal anthrax may be fatal once symptoms appear, in spite of treatment. Supportive therapy may be necessary. Vaccines are available for humans who have a high risk of infection.

Morbidity and Mortality

In most countries, cases of anthrax occur infrequently and sporadically, mainly as an occupational hazard among veterinarians, agricultural workers, and workers who process hides, hair, wool and bone products. The cutaneous form accounts for more than 95% of natural anthrax infections. The intestinal form is rare but can occur in outbreaks associated with contaminated meat. Natural cases of inhalation anthrax are rare; however, aerosolized biological weapons would be expected to produce a high percentage of this form.

Estimates of the case fatality rates of untreated cutaneous anthrax range from 5 to 25%, while treated cutaneous anthrax has a very low mortality rate. Untreated pulmonary and intestinal infections are almost always fatal; these infections may also be recognized too late for effective treatment. The case fatality rate for the intestinal form is estimated to be from 25% to 75%; the case-fatality rate for inhalational anthrax probably approaches 90 to 100%.

Internet Resources

Animal Health Australia. The National Animal Health Information System (NAHIS)
http://www.brs.gov.au/usr-bin/aphb/ahsq?dislist=alpha

Centers for Disease Control and Prevention (CDC)
http://www.cdc.gov/ncidod/dbmd/diseaseinfo/anthrax_t.htm

FAO Manual on meat inspection for developing countries
http://www.fao.org/docrep/003/t0756e/t0756e00.htm

Material Safety Data Sheets –Canadian Laboratory Center for Disease Control http://www.hc-sc.gc.ca/pphb-dgspsp/msds-ftss/index.html#menu

Medical Microbiology
http://www.gsbs.utmb.edu/microbook

The Merck Manual
http://www.merck.com/pubs/mmanual/

The Merck Veterinary Manual
http://www.merckvetmanual.com/mvm/index.jsp

USAMRIID's Medical Management of Biological Casualties Handbook
http://www.vnh.org/BIOCASU/toc.html

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