

Review Article

An overview of *bacillus anthracis* bacteria, one of the most important biological agents

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Abstract: So far, more than 1400 human pathogens have been identified. Of this number, more than 60% have a common origin between humans and animals, which infect humans through animal reservoirs. These diseases include viruses such as influenza, less common (but fatal) diseases such as rabies, and neglected parasites such as *echinococcosis* and *cysticercosis*. The subcategory of bacterial zoonoses also varies, with pathogens common in industrial settings (including *salmonella* and *bartonella henselae*, the causative agent of cat-scratch disease) and diseases more associated with impoverished tropical regions (such as melioidosis and leptospirosis). In this article, we will examine the *bacillus anthracis* bacteria that causes anthrax, which is one of the most important bacteria (the cause of zoonotic diseases) and is also considered one of the agents of bioterrorism.

Keywords: zoonoses diseases; anthrax; bioterrorism

1. Introduction

The use of the disease as a weapon has a long and glorious history. In the early 4th century BC, herodotus was written about scythian archers infecting their arrows before firing at their enemies at the decomposing bodies of humans and snakes. The deliberate use of smallpox as a weapon of war against Native Americans has historically been proven during the Franco-Indian War. Organized biological warfare programs, fully aware of the Koch hypotheses and the pathogenic theory of microbes, began on a small scale during World War I, but expanded dramatically during the years between World War I and World War II^[1].

After the war, the United States and the Soviet Union had expanded biological warfare programs until the signing of the convention on the prohibition of the development, production and storage of bacteriological (biological) and toxic weapons and their destruction (or BWC) in 1972. However, despite the BWC, countries continued to conduct research on bioweapons, as evidenced by the accidental publication of *bacillus anthracis* in 1979 in the city of Sverdlovsk (Sverdlovsk) in Russia^[2,3]. In recent years, NGOs, such as rebels, sects, and terrorist movements, have played a bigger role in the use of bioterrorism, the most important of which was in 2001 by the United States, which was the deliberate sending of *B. anthracis* spores.

Although the three diseases (anthrax, plague, and tularemia) in question are considered very dangerous biological weapons, it is important to recognize that natural cases of these diseases are much more common than those of bioterrorism. In fact, only anthrax scars have clearly been used as a terrible weapon against human targets in modern times. (Which is distinguished by chemical weapons. Used many times in many cases) despite this, it is very important that all cases of these diseases are quickly reported to regional and national health authorities in order to protect patients, employees of the health and public health sector

whenever they are suspected^[2].

1.1. *Bacillus anthracis*

Bacillus anthracis is an aerobic, gram-positive, sporadic bacterium that occurs naturally in soil in many regions of the world. It is the cause of anthrax disease, which is commonly seen in herbivores in soils contaminated with this bacterium. It may also be transmitted to humans through exposure to infected animals through consumption of dairy products inhalation of spores in wool or skin inoculation through the skin or from injections of infected drugs^[4,5]. Shortly after the September 2001 terrorist attacks in the United States, public fear was sparked by the incidence of 22 cases of anthrax due to the sending of hogs to characters by post^[6,7]. *Bacillus anthracis* contains three proteins that are encoded by plasmid. These antigens include the protective antigen, the edema factor, and the lethal factor. The protective agent is connected to two other factors, the edema factor and the fatal factor, causing damage^[8]. The edema factor disrupts the homeostasis of intracellular water and causes edema. The deadly toxin stimulates the production of tumor necrosis factor-alpha and interleukin 1-beta, which leads to lysis of macrophages, the release of inflammatory mediators, organ failure and ultimately death^[9].

1.2. Clinical manifestations of anthrax

Apparent anthrax syndromes vary depending on the contamination pathway. 95% of cases are related to the black form of the scar, which is caused by direct insemination of *B. anthracis* spore through skin damage or injection, resulting in the conversion of the spore form into a bacterial form that causes soft tissue necrosis, the formation of a anthrax “charcoal-like” area without pain. This area disappears within 3 weeks of onset^[10]. Fever, lymphangitis and painful lymphadenopathy are usually associated with lesions. Mortality in this form is 10 to 40 percent if left untreated^[11] (**Figure 1**).



Figure 1. Anthrax scar lesion.

1.3. Anthrax gastrointestinal and pharyngeal anthrax

Digestive and pharyngeal anthrax sores are rare forms of anthrax sores that have been reported mostly in rural areas of developing countries (including sub-Saharan Africa, as well as East, South and Central Asia). Both of these forms occur after eating contaminated and uncooked meat. In anthrax uropharyngeal, edema and mucous anthrax occur with the formation of a false membrane of the larynx, along with the ability to obstruct the airway. Anthrax are very fatal and necrosis occurs throughout the digestive tract, resulting in pain, fever, nausea, bloody diarrhea, visceral perforation, and sepsis. In the oropharynx form, false membranes are seen in the oropharynx, and upper airway obstruction can occur. In digestive form, necrosis infection progresses from the esophagus to the cecum. Fever, nausea, vomiting, abdominal pain, gastrointestinal bleeding and bloody diarrhea are common symptoms. Death is caused by intestinal perforation or sepsis^[12,13].

1.4. Anthrax breathing or inhalation

Respiratory anthrax sores are the most deadly form of the disease, caused by the entry of *B. anthracis* spores into the alveoli following inhalation. Following phagocytosis by pulmonary macrophages, *B. anthracis*

is transmitted through the lymph to the mediastin lymph nodes. After a communal period that may last between 10 and 60 days, the spores germinate, releasing the fatal edema factor and poison, which cause an often fatal disease. anthrax clinical garlic has two-phase inhalation anthrax, with an early nonspecific syndrome including fever, dry cough, shortness of breath, chest pain and muscle pain that may resemble a typical viral respiratory infection. After 2 to 3 days, severe illness occurs with hemorrhagic mediastinitis, respiratory failure and shock^[14]. Media dilation and severe dehydration are common symptoms and findings. In the airspace of the lung coders are less common in chest radiography, but a hemorrhagic necrosanitary pneumonitis is observed in autopsy samples^[15]. Pericardial and ascite irrigation have been reported in 17% and 21% of victims of the Russian province of Sverdlovsk, respectively, that this state may require evacuation^[16]. In anthrax, inhalation is a common bacterium that may occur in half of these anthrax, secondary meningitis, which requires invasive treatment^[16] (**Figure 2**).



Figure 2. Anterior posterior chest radiography in a patient with inhaled anthrax.

In Scotland, the United States advanced anthrax diagnoses are available through the CDC, the US Army Medical Research Institute for Infectious Diseases (USAMRIID; US Army Medical Research Institute for Infectious Diseases) and the Naval Medical Research Center (NMRC; Naval Medical Research Center), serological, immunohistochemical, and polymerase chain reaction (PCR) tests^[17]. Recommended clinical samples include culture and blood, serum for antibody testing, plasma for direct detection of the deadly agent, cerebrospinal fluid, cerebrospinal fluid, and biopsy of skin scars. The complete guide on the CDC website is addressed to <https://www.cdc.gov anthrax/specificgroups/lab-professionals/recommended-specimen.html> available.

2. Treatment

Treatment of anthrax disease varies based on clinical form and is divided into meningic and non-meningic disease for antimicrobial treatment. Depending on the severity of the treatment, it is recommended that patients be diagnosed through premature lumbar puncture be confirmed and then treated against meningitis^[18]. With or without meningitis, respiratory anthrax have extremely high mortality even with treatment. Despite this, the general principles of critical care respiratory support should be carried out.

Experimental management of anthrax antimicrobial involves an intravenous fluoroquinolone (such as ciprofloxacin, levofloxacin, or moxifloxacin) with a carbapenem (mropenem or amipenem) and a protein synthesis inhibitor or rifampin. Clindamycin or linzolid are acceptable as a protein synthesis inhibitor. Rifampin indirectly blocks protein synthesis by inhibiting RNA polymerase (and thus mRNA synthesis) and appears to have comparable efficiency. In a disease with a non-meningic form, treatment may be obtained with fluoroquinolone or carbapenem in combination with a protein synthesis inhibitor. Once antimicrobial

sensitivity has been established, penicillin G or intravenous ampicillin may be used instead of carbapenem for sensitive isolates.

Due to the high risk of maternal and fetal death in anthrax infections, pregnant women should receive the same treatment as non-pregnant adults^[19]. Uncomplicated anthrax skin can be treated with oral ciprofloxacin or doxycycline for 7 to 10 days. But since there is a possibility of simultaneous inhalation form, a long course of treatment of 60 days is usually preferred. In addition to antimicrobial drug treatment, routine intensive care support measures should be provided for ill patients with anthrax. Peritoneal fluids and ascites may play a role as a repository of the deadly poison^[20]. Although there is limited information about the use of auxiliary corticosteroids, the deadly poison appears to suppress the glucocorticoid receptor^[21].

The combination of antibiotics and (if any) corticosteroids, immunotherapy can be used if available. Raxibacumab and obiltoximab are two monoclonal antibodies used against the protective antigen^[22–26]. Intravenous black anthrax immunoglobulin (aigiv) is a pure polyclonal obtained from vaccinated donors^[27]. All three have been confirmed or have drug status in the United States and the European Union, but none are commercially available and must be sourced from the CDC's strategic national warehouse. In the absence of comparative human trials, all three are suitable options that should be prescribed to suspected or confirmed anthrax victims.

Prevention for patients exposed to anthrax

Prevention for patients who are exposed to anthrax should include oral ciprofloxacin (500 mg twice daily), levofloxacin (750 mg daily) or doxycycline (100 mg twice daily) for 60 days, regardless of test results. Nasal swab testing (cultured or PCR) can confirm exposure to anthrax in large groups—people exposed to penicillin-sensitive strains may receive oral penicillin or high-dose amoxicillin for prevention under limited conditions, but preferably fluoroquinolones or doxycycline are prescribed^[17].

The anthrax vaccine (AVA-Biothrax, BioPort Corporation, Lansing, Michigan, US) is the only human anthrax vaccine licensed in the United States and licensed in Italy, Germany, Britain, France, the Netherlands, Poland and Singapore. Since 2018, the vaccine has been derived from substances produced from the cultivation of a strain of toxicity and capsule presence. Almost 95 percent of people have serum titers after the third round of this conversion vaccine. The US military is currently using a series of six doses. Headaches and other systemic symptoms were reported in 1% of US Army recipients, as well as 6.3% of people had reactions at the injection site^[22].

3. Conclusion

Anthrax are quite prone to antibiotic treatment, and clinical garlic is often so fast that infected animals may not be treatable. Therefore, it is necessary to focus on control strategies in areas suspected of anthrax. Recommended strategies in anthrax control include immunization, quarantine, and proper carcass maintenance and disposal. In addition to control strategies, the implementation of appropriate hygiene procedures in slaughterhouses and dairy industries ensures the safety of products of animal origin intended for human consumption. The information in this study helps decision-makers in the country's health sector to improve the technical capacity of regional and national medical and veterinary services.

Author contributions

Conceptualization, PK and MNA; validation, NS, AJ and PK; investigation, PK; resources, PK and MNA; writing—original draft preparation, PK; writing—review and editing, PK and MNA; visualization, NS and AJ;

supervision, NS and AJ; project administration, PK. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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