Anthrax and its Impact on Public Health

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ABSTRACT

Anthrax is an acute, febrile, infectious disease of animals and humans associated with Bacillus anthracis, a gram-positive, rod-shaped bacterium. This bacterium is capable to form highly resistant spores under appropriate condition and proficient of persisting their virulence efficacy for many years. Bacillus anthracis is a complex organism that has three protein parts referred to as components I, II, and III. All vertebrates are susceptible to this disease, however, sheep and cattle are the most frequently affected, whereas horses and goats are less frequently affected. Humans can also develop the disease by eating the meat or handling the hair, bones, wool or carcasses of affected animals. It occurs as a cutaneous, pulmonary or intestinal infection in humans. Severe outbreaks of the disease are usually encountered in the region having tropical and sub-tropical climates, where there is high annual rainfall. The clinical signs include skin lesions (90-95%), cough, chest pain, malaise, and fever. Early symptoms show similarity with flu-like illness. Within 3-6 days, rapid hypoxia, elevated temperature, and mediastinal widening might occur. Meningitis also develops in later stages. The mortality rate is nearly 100% if left untreated. Mortality can be decreased by commencing an appropriate protocol of antibiotics. Antimicrobial treatment is often useless in the case of acute Anthrax, however, treatment should be initiated within 24 hours of the first sign of the infection. The treatment can be done with streptomycin, penicillin, tetracycline, chloramphenicol, and erythromycin. The line of treatment should be followed for five days.

Key words: Cutaneous infection, Zoonosis, Public Health, treatment, antimicrobials.

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1. INTRODUCTION

Anthrax, a lethal infection, is also infectious and highly transmissible (Fulako 2004). The gram-positive bacteria *Bacillus anthracis*, which typically exists in the soil in endemic zones and is capable of spore formation, is what causes anthrax. Non motile by locomotion, *B. anthracis* is anaerobic and produces centrally located spores. Taxonomically, the causative organism belongs to the Bacillaceae family (Shafazand et al. 2001).

Generally, anthrax affects a wide range of animals, including domestic and wild animals worldwide. *B. anthracis* can infect food animals, most commonly sheep, cattle, goats, and horses. Some species show resistance to the organism, such as birds are very resistant. Similarly, pigs are more resistant than horses and sheep. Whereas in pets, such as dogs and cats, are also resistant. The majority of anthrax cases occur in non-vaccinated animals. Humans are also at risk of developing Anthrax when they come into contact with the remains of the infected animals or the infected animals themselves. It is mainly an industrial hazard for workers that deal with bone products, processed hides, wool, goat hairs, and infected wildlife. Contact with infected meat is also a source of it (Baron et al. 1994). Humans can acquire anthrax from an infected animal or animal which has been expired due to this disease or by exposure with by-products contaminated with this pathogen (Sidwa et al. 2020).

A human can be infected with this bacterium through the gastrointestinal tract (gastrointestinal Anthrax), skin lesions (cutaneous Anthrax), or respiratory routes (pulmonary Anthrax) (Dixon et al. 1999). The two forms in which *B. anthracis* occurs are vegetative cells found inside the body and spores for persistence in the environment or soil (Santelli et al. 2004). It is primarily found in the endospore form in the soil, which allows it to continue to function in this form for many years. The potential and lethal use of *B. anthracis* is a bioterrorism agent in which spores formed by this bacterium can be sprayed and aerosolized to remote areas to spread disease. The events of 2001, however, have verified and made clear that bioterrorism linked to this bacterium is not merely a danger, but rather a reality (Jernigan 2001). *B. anthracis* has a tripartite toxin and a poly-D- glutamic acid capsule as its two main virulence factors (Jernigan 2001). In order to hide from the body's macrophages, Pathogenic *B. anthracis* forms a capsule that resembles the host's immune system (Mock and Mignot 2003). The tripartite toxin of this bacterium is composed of three separately secreted proteins: lethal factor (LF), edema factor (EF), and protective antigen (PA) (Mock and Mignot 2003; Turk 2007). A binary A-B toxin, edema toxin (ETx) and lethal toxin (LTx), respectively, are created when anthrax toxin functions as the binding/linking (B) domain and EF and LF act as the active (A) domains (Singh et al. 1999). The bacterium multiplies significantly following contact with skin lesions or ingestion and kills the infected host, whether human or animal, within a few days or weeks. Anthrax disease is not a problem in developed nations because only a minimal number of cases have been documented. However, in countries where agriculture is the only source of income, cutaneous anthrax poses a serious threat to public health. Although anthrax has been linked to humans for a long time, it only recently gained public attention following incidents in the United States in September 2001.

2. EPIDEMIOLOGY

2.1. OCCURRENCE

Historically, this disease originated from sub–Saharan Africa and later spread to various countries worldwide. The prevalence of this illness varies depending on the environment, the soil, and the activities that promote the spread of *B. anthracis* globally. As a result, just because they are isolated from one atmosphere does not necessarily mean that that environment is in their habitation (Foster and

Slonczewski 2017). The more frequent origins of this disease are inadvertently consuming filthy bone meal or pasture by tanner effluent. However, there are few outbreaks, and the affected animals are small. In most countries, compared to satirical incidences, there is a significant decline in its occurrence by developing an active live stokes vaccine coupled with penicillin and implementing the quarantine protocol and regulations (Read 2003).

The contaminated soil is the definitive reservoir of the causative agent, and spores of the bacterium remain viable for decades. The major host of the disease, herbivores, become infected more quickly when they forage in a polluted area. Because the causative organism does not solely rely on a host reservoir, it is difficult to remove from an area, which explains why it is still endemic in many nations (Carter and Wise 2004). Products from infected animals and contact with infected animals are the exclusive sources of human infection. Classification of human Anthrax varies widely depending on the direct contact or handling. Suppose a human acquired the disease directly from the infected animal. In that case, it is considered nonindustrial, whereas it is industrial if a human gets this disease while handling an infected animal's contaminated products. Veterinarians, butchers, and farmers are usually affected by nonindustrial Anthrax as they work with animal carcasses or their byproducts. On the other hand, management of contaminated hides, wool, hair, bone meal, or byproducts led to the development of industrial anthrax. Due to dust inhalation that contains spores, industrial anthrax is more likely to cause lung disease (Constable et al. 2016).

2.2. RISK FACTORS

2.2.1. HOST FACTOR

All vertebrates are susceptible to the disease, however sheep and cattle are the most frequently affected, whereas horses and goats are less frequently affected. Humans dominate this group, whereas pigs, cats, and dogs are relatively resistant. In farm animals, Anthrax is invariably lethal, except in resistant animals like pigs, and in these species, the case ratio and fatality are also high (Read 2003).

2.3. AGENT FACTOR

The lethal factor (LF) and edema factor (EF) sections both contain virulence factors that contribute to the virulence of the virulent strains. Toxins associated with spore-forming units are termed protective antigens. *Bacillus anthracis*'s primary virulence factors are its capsule and toxins. *Bacillus anthracis* is a complex organism that has three protein parts referred to as components I, II, and III. Edema factor (EF), lethal factor (LF), and protective factor (PF) make up their first, second, and third components, respectively.

Each basic component also has one mobile protein. The elements that enter the host cells include LF and EF, which compete for binding with the protection factor (PF), which has a role in membrane translocation (Paccani et al. 2007). These three crucial elements combine their effects to give *Bacillus anthracis* its poisonous properties. There is relatively low mortality when the infection is caused by component one and two, and lethality reaches a maximum when component three also act with the first two components. Only those virulent strains encapsulated toxigenic (Carter and Wise 2004).

2.4. ENVIRONMENTAL FACTOR

In climates including tropical and sub-tropical, where there are high rainfalls annually, the infection persists more in the soil, and severe outbreaks of the disease are usually encountered. Every summer, the outbreak

spreads over African nations, and in certain years, when there has been a lot of rain, it has intensified to a terrible rate. During this time, wild species including hippos, elephants, and cape buffalo experience large mortality rates. Predators may act like disease carriers, which could be the cause (Constable et al. 2016). A soil-borne illness can cause periodic outbreaks in areas with cool, temperate climates.
For instance, strong rain following a protracted drought, a dry summer following a protracted heavy rain, and always in warm weather with a constant temperature of 15°C. There is improbability in the hypothesis that these conditions result in vegetative proliferation and sporulation with the production of Anthrax. However, spores consist of a greater buoyant density and become concentrated in the wet soil, which helps them to remain suspended in the still water and allows further concentration on the soil as the water evaporates. The climate relationship has made the prediction of anthrax life expectancy easy in the soil (Van Ness 2008).

2.5. TRANSMISSION

Infectious agents enter the host body by various means, including inhalation, ingestion, or through the host's skin. Organisms spread in the body's area by insects, streams, carnivores, dogs, wild birds, and contaminated feces from the infected animals. In the new areas, contamination usually occurs through contaminated animal products, including fertilizers, hides, wool, bone meal, or contaminated forage, concentrates, or other feeds. Infection through inhalation is of minor importance, but the possibility of infection through dust should always be in mind. In wool and hair industries, inhalation of spores by workers is the primary source of Wool Sorter's disease (Constable et al. 2016).

3. PATHOGENESIS

After inhalation through the pulmonary route, the bacterium needs a lesion that helps it to enter the host's body, following germination of the spores and is carried to the lymphatic system, where multiplication occurs. During the incubation period, bacteria are filtrated by the reticuloendothelial system and spleen. Last but not least, the toxin's impact causes the system to breakdown in the final hours of life. Toxins cause the endothelial cell lining of the veins to break down, which ultimately leads to internal bleeding. Moreover, in systemic disease, they induce lethality in target tissues (Moayeri 2015). After ingestion of the spores, there is the development of infection through the mucous membrane, in the epithelium surrounding the erupting teeth, fibrous foodstuff, and through scratches. The causative organism is resistant to systemic phagocytosis due to the presence of factor D-glutamic acid capsule, which stimulates its proliferation in draining lymph nodes and eventually reaches into the bloodstream, passing through the lymphatic vessels and causing septicemia. This septicemia results in a massive invasion of body tissues, and a lethal toxin causes tissue damage and edema. Ultimately, there is cell death from the cumulative effect of shock, terminal anoxia, and acute renal failure (Foster and Slonczewski 2017).

4. CLINICAL FINDINGS

4.1. CLINICAL FINDINGS IN ANIMAL

Obligate causative agent by nature, the typical incubation period for this virus is 3-7 days, while it can occasionally last up to 14 days. The disease's progression in herbivores, however, ranges from chronic to acute (Hungerford 1990).
Some of the clinical findings in per acute form of the disease in sheep, cattle, or goat that has no previous history of ill are a few convulsions, collapse, sudden onset, dyspnea, trembling, and staggering (ss

(Carter and Wise 2004). There might be complete or partial absence of rigor mortis in affected animals. At the mouth, nostrils, anus, or vulva, black, tarry-like dark blood does not clot in these animals (Collins and Huey 2015).

A sudden increase in body temperature, excitement, cardiac, pulmonary distress, depression, convulsion, and death are present clinical findings that can be seen in acute form. Due to the 41.5°c rise in temperature, there may be abortion or lack of rumination. Bleeding may occur from several natural orifices of the body, mainly lasting about 36-48 hours (Hungerford 1990). In relatively resistant animals like pigs and horses, fever, listlessness, edema of body tissues, petechial hemorrhage, and anorexia are common clinical findings. At the nostrils, bloody froth may be seen with dysentery (Collins and Huey 2015). On the other hand, subcutaneous edematous swelling present locally at the ventral neck, thorax, and shoulders characterized the chronic form of the disease.

4.2. CLINICAL FINDINGS IN HUMAN

More than 90–95 percent of human cases manifest the illness on the skin. Areas of exposed skin become itchy and develop sores. These lesions develop and pass-through various stages, including vesicular, with a blister becoming hemorrhagic, a popular eschar that develops 2-6 days after the hemorrhagic stage. These vesicle dries and ultimately transform into a depressed dark black scab. This black scab is a malignant pustule with widespread swelling (edema) and redness. The disease lesions are usually without pain, but surrounding edema results in pain in the body. If left untreated, lesions can reach the lymph nodes (regional). In severe cases, septicemia can be seen. Overall, untreated cases have rare death events if early treatment occurs, but the case fatality rate varies from 5% to 20% (Nijm and Hugh-Jones 2001).

The inhalation form of the disease is rare and can be seen with little and non-specific clinical signs such as cough, chest pain, malaise, and fever. Early symptoms show similarity with flu-like illness. Within 3-6 days, rapid hypoxia, elevated temperature, and mediastinal widening might occur. In this case, the mortality rate is nearly 100% if left untreated. Meningitis also presents. Mortality can be decreased by commencing an appropriate protocol of antibiotics (Collins and Huey 2015).

In other forms, the oropharyngeal or intestinal form is rare, and there is no outbreak in developed countries, but there are massive outbreaks of these forms in developing countries. The main reason for these outbreaks is ingesting contaminated meat from infected animals. There may be GIT symptoms associated with septicemia, fever, and ultimately death of the host. In this form, the case fatality rate reaches 25-75%. However, in oropharyngeal Anthrax, lymphadenopathy leads to neck swelling, throat pain, oral ulcers, fever, and dysphagia, ultimately resulting in death dur severe swelling and septicemia. Reports showed it has similar fatality rates to the intestinal form (Collins and Huey 2015).

5. TREATMENT

The causative agent shows susceptibility to several drugs, including streptomycin, penicillin, tetracycline, chloramphenicol, and erythromycin. The line of treatment should be followed for five days. Antimicrobial treatment is often useless in the case of acute Anthrax (Hirsh and Zee 2003). If treatment is initiated 24 hours after the infection, then the above-listed antibiotics can act as a life-saving drug during treatment. Multiple animal deaths may be seen after the treatment is stopped. The degree of protection to the animal through antibiotics varies from 10-90%. After the end of treatment, the combination of antibiotics and protective antigen vaccine can fully protect all the animals. Numerous animals whose handling was postponed after 24 hours post-infection were found to have varying degrees of toxemia and bacteremia (Schlomovitz et al. 2011).

6. CONTROL AND PREVENTION

Whenever an outbreak of the disease occurs, health authorities related to animals must be informed to ensure control measures such as for carcass disposal, the carcass should be properly burned or buried deep. Control methods, such as the treatment and isolation of sick animals, the immunization of sensitive stocks, and the longer-than-three-week-long quarantine of the sites, must be closely monitored. The milk of sick animals should be discarded using the proper procedures. It is required to use 10% NaOH (sodium hydroxide) to disinfect burns and fences. If treated with 3% acetic acid at a rate of 8 Liters/square meter, boiling utensils for 30 minutes will aid in the death of all types of spores (Hirsh and Zee 2003).

The control and elimination of the disease rely heavily on vaccination. Although the vaccines act as protective, they sometimes initiate several reactions in the host's body. One of the vaccines derived from an encapsulated strain has proved to help control the disease. This vaccine provides immunity for at least one year, whereas vaccines obtained from living antigens do not provide immunity (Sharma and Adlakha 1996).

For the control of Anthrax, the control of milk and meat-producing animals play a vital role in avoiding the risk to the human population. Avoid unnecessary waste. During an outbreak, quarantining the farm, diverting attention to cadavers and discharge, and immunizing survivors indirectly reduce human exposure to animal diseases. Moving milk and meat from the farm is prohibited during the quarantine period to stop the disease from getting into the food supply. Putting an end to the infection cycle begins with stopping the infection source. Getting other animals out of the afflicted area as soon as possible is vital. Therefore, fly control should be considered if flies are suspected of being significant vectors. For imported animal products from specific regions, formaldehyde must be used to disinfect materials like hair and wool. Sterilize bio-endemic foods using steam for 15 minutes at 115°C or dry heat for 3 hours at 150°C (Hirsh and Zee 2003).

7. IMPACT ON PUBLIC HEALTH

Anthrax predominantly impacts herbivore animals. Contact with sick animals or their waste products is the most common way humans become ill. People who work with hides, goat hair, bone products, wool, and contaminated wildlife are most at risk of contracting anthrax. Additionally, it can be caught by contact with infected meat, such as from workers at an abattoir. New infection sites in animals may emerge as a result of the introduction of animal feed containing bone meal. When handling pet meat or working in a knackery, people can suffer cutaneous rashes. Anthrax can also be employed as a bio-warfare or bio-terrorism agent and is most likely dispersed as an aerosol; therefore, any new case should be evaluated with this possibility in mind, particularly but not primarily in cases of pulmonary Anthrax (Nijm and Hugh-Jones 2001).

In some nations, anthrax epidemics still have a high risk, occasionally affecting people. According to estimates, each anthrax-infected cow in Africa may cause up to ten human cases. However, in wealthy countries, anthrax cases have significantly decreased. In the early 1900s, there were over 130 human cases per year in the U.S., but today, there are often only one or two cases of cutaneous Anthrax per year. Anthrax cases are rare and intermittent in many nations, mostly among veterinarians, agricultural workers, and people who produce items made of hides, hair, wool, and bones. At least 90–95 percent of all naturally occurring anthrax infections occur on the skin. Although it appears less common, outbreaks linked to tainted meat can also involve the gastrointestinal form. Although inhalational Anthrax is uncommon, aerosolized biological weapons should create a significant amount of this type. 11 instances of cutaneous and 11 cases of inhalation anthrax were associated with a bioterrorist attack in 2001 that used mail that was infected with anthrax. The death rate is impacted by the disease's form. According to estimates, 5-

20% of cutaneous anthrax cases that go untreated result in fatalities, but less than 1% of those who receive antibiotic therapy do. In contrast, even with the proper care, inhalational Anthrax has a high fatality rate. Older, more extensive treatment regimens may reduce the mortality rate, although earlier estimates estimated that the case-fatality rate for this variety was close to 90% to 100% (Nijm and Hugh-Jones 2001).

8. PUBLIC HEALTH ACTION RECOMMENDED

- With the proper legislation for meat handling and efficient animal immunization, anthrax disease can be avoided—regulations governing the sale of meat and hygienic procedures at slaughterhouses. Before being killed and sold, animals intended for human consumption should be inspected.
- Coordination with the veterinary and animal husbandry departments, surveillance, and a cow vaccination drive.
- The hamlets provide the locals with highly critical one-line health education input as part of a behavioral change communication campaign for anthrax avoidance. Avoid raw meat and thoroughly prepare it before eating to reduce your risk of getting Anthrax.
- The inoculation of animals against Anthrax is crucial. Breaking the cycle of poverty and infection is one of the most effective ways to provide health security to the great majority of disadvantaged groups and keep them from further falling into poverty.

9. CONCLUSION

Anthrax is a zoonotic disease and is of major concern for both humans and animals. This disease can be transmitted from affected animals or from the carcass of affected animals or their by-products. The spores of this bacterium can tolerate environmental conditions and can persist in soil for several years. In this way, soil acts as a main reservoir for domestic and wild mammals. Outbreaks of anthrax in different species of animals have been reported. Suspected cases should be confirmed by performing laboratory tests. As this disease is zoonotic, so we can eliminate the risk for humans by controlling and managing this disease in animals. This can be done by proper disease surveillance, outbreaks investigation, quarantine of affected animal, awareness among animal owners and persons working at slaughter house, implementing effective vaccination programmes, proper disposal of infected animal carcass and by adopting effective disinfection procedures.

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