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Abstract. More cutaneous anthrax cases were noted at Hospital Albert Schweitzer (HAS) in the Artibonite Valley of Haiti. We examine the incidence of anthrax in the Artibonite between 1992 and 2002, describe the clinical presentation of cutaneous anthrax, and determine risk factors for anthrax. In 1992 HAS reported 1 case of anthrax for an incidence of 4 cases per million persons/year. In 2002, there were 20 cases of anthrax for an incidence of 72 cases per million persons/year. This is a 17-fold increase (P = 0.0002). Causes of death from anthrax included asphyxiation from edema of the neck with tracheal compression and concurrent gastrointestinal anthrax. Butchering cattle that had died of illness was identified as a risk factor. The incidence of human anthrax has increased in the Artibonite Valley and is a cause of significant mortality. Control of anthrax in humans depends on improved animal vaccination programs.

INTRODUCTION

Recognizing the many clinical manifestations of cutaneous anthrax is important in countries with endemic anthrax and in other countries in the modern era of bioterrorism and biologic warfare. The case of the 7-month-old infant in the United States with cutaneous anthrax associated with microangiopathic hemolytic anemia—a previously unrecognized complication of anthrax—illustrates the gaps in our knowledge about the various manifestations of cutaneous anthrax, particularly in children. In future outbreaks, a case of cutaneous anthrax in a patient with no other risk factors could be the first evidence that a bioterror attack has occurred. In countries with endemic anthrax, 95–99% of cases are cutaneous. In the September 2001 release of weaponized anthrax spores through the US Postal Service, 11 (50%) of 22 cases presented with cutaneous disease. Understanding the symptoms, signs, and associated morbidity and mortality of cutaneous anthrax will help clinicians to promptly recognize and appropriately manage this disease.

We report an investigation of cutaneous anthrax in Haiti’s Artibonite Valley. Reports of anthrax in Haiti date back to the eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with and eighteenth century, when an epidemic consistent with. The World Health Organization (WHO) lists Haiti as 1 of 18 countries worldwide with hyper-endemic anthrax. Anthrax in Haiti is most commonly reported from the country’s southern peninsula and until recently was relatively rare in the Artibonite Valley, which is located 100 miles north of Port au Prince. In this report we examine the incidence of human anthrax in Haiti’s Artibonite Valley over a 10-year period, describe the clinical presentation of cutaneous anthrax in adults and children, and determine risk factors for anthrax.

METHODS

Study location. Hospital Albert Schweitzer (HAS) is a non-governmental organization working in partnership with the Haitian Ministry of Health and serving a population of ~250,000 people of Haiti’s Artibonite Valley (Figure 1). HAS provides three levels of health care: community health workers in each village, primary care dispensaries in each of 14 rural zones, and a central referral hospital. All patients with acute illness are first seen by a medical officer in their primary care dispensaries, and if necessary referred to see a physician at the referral hospital. HAS and affiliated dispensaries are the sole health care providers for the population in the catchment area. Therefore, all patients who sought medical care for anthrax in the HAS district would have been seen in a dispensary or the hospital. The Schweitzer Hospital has one of the longest running and most comprehensive population-based health information systems in Haiti. The information system includes a household survey conducted every ~10 years, data from community health workers on pregnancies, births, deaths, vaccinations, and children’s weights, and clinical data. The health information system of HAS has been a critical source of data on the health of rural Haiti for 35 years.

Study design. The current investigation is composed of three parts:

1) Incidence of reported cases of suspected anthrax between the years 1992 and 2002
2) Clinical case review of patients diagnosed with anthrax between 1998 and 2002
3) A prospective case control study of patients diagnosed with suspected anthrax in 2002 to determine risk factors for infection

Incidence of reported cases of cutaneous anthrax, 1992–2002. We report the incidence of reported cases of anthrax in each year between 1992 and 2002 as anthrax cases per 1 million persons per year. For each case of anthrax diagnosed at HAS, a national case report form must be completed. The case report form includes a checklist of clinical criteria that must be present for a case to satisfy the WHO clinical definition for suspected cutaneous anthrax. Criteria for cutaneous anthrax are: a skin lesion evolving over 2–6 days, starting as a papule or vesicle, ulceration, surrounding edema, and development of a black eschar. The hospital records the number of cases of anthrax reported to the government in monthly morbidity and mortality reports. We reviewed these reports for the past 11 years and recorded the number of cases of anthrax reported per year from 1992–2002.

The population of the hospital district was estimated from periodic household surveys conducted by the HAS Commu-
nity Health Department since 1968. A survey conducted in 1995 estimated the population of the service district at 250,000. To estimate the population in other years between 1992 and 2002, we assume a population growth of 1.5% per year in intervening years.

Clinical case review of patients diagnosed with anthrax, 1998–2002. We reviewed the medical charts of all cases of suspected anthrax diagnosed between 1998—when an increase in human cases was noted—and 2002 using a structured data collection form. Each patient treated at HAS has a medical chart with a unique identifier number. We generated a list of all anthrax cases and their hospital identifier numbers by review of the hospital logs and the morbidity and mortality reports for the past 5 years. We then retrieved the medical charts and reviewed them. Data summarized from the charts included age, sex, date of diagnosis, place of residence, clinical presentation, treatment, clinical outcome, and clinical laboratory data.

Case control study of cutaneous anthrax diagnosed in 2002. A case control study to identify risk factors for anthrax was prospectively conducted in 2002. The study was conducted by physicians to promptly guide the public health response to the growing number of cases of anthrax seen at the hospital. All patients diagnosed with anthrax at HAS were interviewed by a physician fluent in Haitian Creole using a structured questionnaire on exposure history to animals and animal products. For children, a parent or guardian was also interviewed. Controls were matched for age (+/− 2 years), sex, and dispensary of attendance. Within 1 month of interviewing the case, the physician interviewer visited the primary care dispensary of the rural zone where each case presented and questioned a patient seeking primary care services matched by age and sex to the case. Risk factors for anthrax were compared between the cases and controls.

Analysis methods. Data were analyzed using EPI info 2000 (Centers for Disease Control and Prevention, Atlanta, GA). For categorical variables, frequency and proportions were computed, whereas for continuous variables, median and ranges are presented. The incidence of anthrax is reported as cases per million population per year. Proportions are compared using Fisher’s exact test; risk ratios with 95% confidence intervals (CI) are reported. Means and medians are compared by Student’s \( t \) test and the Wilcoxon rank sum test respectively. A \( P \) value of less than 0.05 was considered statistically significant.

The study was approved by an institutional review board (IRB) at the HAS and Cornell University.

RESULTS

Incidence of reported cases of cutaneous anthrax, 1992–2002. In 1992 HAS reported 1 case of anthrax for an incidence of 4 cases per million persons per year. In 2002, there were 20 cases of suspected anthrax reported for an incidence of 72 cases per million per year. This is a 17-fold increase in incidence \( (P = 0.0002) \). Of note, the peak was 25 suspected anthrax cases in 1999 for an incidence of 94 cases per million population per year, a 23-fold increase from 1992 \( (P < 0.0001) \). Figure 2 details the anthrax incidence in each year between 1992 and 2002.

Clinical case review of patients diagnosed with anthrax, 1998–2002. In the 5-year period between January 1, 1998 and
December 31, 2002, 87 cases consistent with the WHO clinical case definition of suspected cutaneous anthrax were reported at HAS (Table 1).

At presentation, the median age of patients was 9 years with a range from 8 months to 89 years. Fifty-eight (66%) of these cases occurred in children under the age of 16.

The most common site of cutaneous anthrax was the face (53 cases, 61%). Of the 53 lesions on the face, 17 were peri-orbital, 11 involved the cheek or jaw, 9 were peri-oral, 1 was on the forehead, and 15 were unspecified.

The most common associated clinical sign was massive edema (Figure 3). Other common signs included fever, local lymphadenopathy, and abdominal pain. Pain at the site of the lesion was reported in only 12 (14%) cases and was mild to moderate.

Twenty-seven patients had blood cultures performed prior to initiation of antimicrobial therapy; 21 were negative, 4 grew gram-positive bacilli and 2 grew coagulase-negative Staphylococcus. Two of the 4 patients with blood cultures positive for gram-positive bacilli died (50% mortality) compared with 0 of 23 of other patients (0% mortality). Three patients had wound cultures and all were negative.

Residents of the four adjoining rural zones of Perodin, Medor, Petit Riviere, and Plassac were at higher risk for presenting with anthrax than residents of other zones in the district (Figure 1). Sixty-nine cases (79%) came from these 4 northern zones, which have a population of 78,732 people, for an incidence of 175 cases per million population per year compared with 19 cases (21%) from the remaining 10 zones, which have a population of 171,268 people, for an incidence of 22 cases per million population per year, risk ratio 7.9 (95% CI 4.7–13.1, \( P < 0.0001 \)).

Between 1998 and 2002, anthrax appeared seasonally in the Artibonite Valley with a peak at the end of the dry season in May and June with a mean of 4 cases per month and a nadir in the rainy months of October and November with a mean of < 1 case per month.

During hospitalization, all patients were treated with intravenous penicillin (1.2 million units per day) for a total course of 14 days per hospital standard procedures. Nine patients (10%) required reconstructive surgery for extensive skin necrosis and 8 (9%) required a prolonged course of antibiotics for secondary infection. Seven patients (8%) died. The essential facts of the deaths are described in Table 2. Four patients died of asphyxiation when facial and neck edema compressed the trachea causing airway obstruction. Two patients died with symptoms consistent with gastrointestinal anthrax. Treatment of the patients who died included tracheotomy for 3 of the patients with airway obstruction and red blood cell transfusions in both patients with gastrointestinal bleeding.

There was no difference in presentation or outcomes between adults and children.

**Table 1.** Characteristics of eighty-seven patients hospitalized with cutaneous anthrax at the Hospital Albert Schweitzer in Haiti, 1998–2002

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>&lt; 5 years</td>
<td>15 (17%)</td>
</tr>
<tr>
<td>5–15 years</td>
<td>43 (49%)</td>
</tr>
<tr>
<td>&gt; 16</td>
<td>29 (34%)</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>39 (45%)</td>
</tr>
<tr>
<td>Female</td>
<td>48 (55%)</td>
</tr>
<tr>
<td>Location of anthrax lesion</td>
<td></td>
</tr>
<tr>
<td>Face</td>
<td>53 (61%)</td>
</tr>
<tr>
<td>Neck</td>
<td>7 (8%)</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>14 (16%)</td>
</tr>
<tr>
<td>Trunk</td>
<td>10 (11%)</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>3 (4%)</td>
</tr>
<tr>
<td>Clinical signs</td>
<td></td>
</tr>
<tr>
<td>Edema</td>
<td>76 (87%)</td>
</tr>
<tr>
<td>Temperature &gt; 39°C</td>
<td>32 (37%)</td>
</tr>
<tr>
<td>Local lymphadenopathy</td>
<td>12 (14%)</td>
</tr>
<tr>
<td>Pain at the site of the lesion</td>
<td>12 (14%)</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>6 (7%)</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The number of patients diagnosed with cutaneous anthrax in Haiti’s Artibonite Valley has increased 20-fold between 1992 and 1999. Cutaneous anthrax occurred in all age groups, including children, and was associated with butchering and...
handling meat from cattle or goats that had died of illness. Causes of mortality from cutaneous anthrax included asphyxiation from massive facial edema and gastrointestinal bleeding from symptoms consistent with gastrointestinal anthrax.

We report an increase in cutaneous anthrax cases in the Artibonite Valley during the past 10 years. This increase may be related to several factors. Ecological changes secondary to Haiti’s deforestation have lead to a cyclical pattern of intense flooding followed by long periods of drought. Such a flood–drought pattern has been called “anthrax weather” because of its association with anthrax outbreaks in pastures in North America. Flooding and subsequent run-off concentrate anthrax spores in low-lying areas; drought evaporates pooled water and further concentrates the spores. The seasonality of anthrax cases at HAS supports the relationship with weather patterns. Finally, Haiti has been beset by political, economic, and social turmoil over the past 15 years; this turmoil has hindered government-sponsored animal health services including anthrax vaccination programs.

The distribution of cases of anthrax within the Artibonite valley displays a clear geographic pattern. The incidence of anthrax in a rural area in the northeast corner of the region was 8-fold higher than the rest of the HAS district with ~80% of cases occurring in this area. Understanding of this geographic distribution enabled HAS to target an animal vaccination program at this area. Educational programs to improve the proper disposal of animal carcasses were also implemented in this region.

Two-thirds of the anthrax cases admitted to HAS between 1998 and 2002 were children. Anthrax has historically been described as a disease mostly affecting adults. Our report and previous reports from Haiti demonstrate that children do contract anthrax and that the morbidity and mortality of cutaneous anthrax in this population is significant. The high incidence of cutaneous anthrax among children in this series may be related to the integral role that children play in butchering animals in Haitian society (Figure 4).

Cutaneous anthrax was associated with significant morbidity and mortality in this case series. Of note were 4 cases of rapidly fatal airway obstruction. All 4 patients died within 48 hours of presentation to HAS. None of these patients were noted to have oropharyngeal lesions on examination but this may have been difficult to appreciate in the setting of severe edema of the face and neck. The asphyxiation in these cases seems to have been caused by a direct, external compression of the airway by severe edema related to anthrax lesions of the face and neck (Figure 3). Asphyxiation from massive edema and tracheal compression has previously been described as a cause of death in cutaneous anthrax in Turkey. These cases clearly illustrate the potentially life-threatening nature of cutaneous anthrax of the face and neck and the importance of rapid intervention.

Current recommendations for management of cutaneous anthrax in patients with systemic symptoms, extensive edema, or involvement of the head or neck now include the use of at least 2 intravenous antibiotics and consideration of steroids. In patients with extensive edema of the head and neck, we also recommend intensive care unit monitoring of the airway and early consultation with a surgical service in case an emergency tracheotomy is needed.
Several had healing eschars consistent with recent infection. These findings are consistent with prior descriptions of cutaneous anthrax that indicate 80–90% of cases resolve spontaneously. Therefore, this case series likely represents only the tip of the iceberg of cutaneous anthrax in the Artibonite Valley.

The second major limitation of this study is that we did not confirm the diagnosis of anthrax by laboratory tests. Therefore, all cases in this report are suspected anthrax by WHO criteria. Current recommendations from the American Academy of Dermatology for laboratory diagnosis of cutaneous anthrax include punch biopsy, serology, and PCR for diagnosis of cutaneous anthrax. Punch biopsy is not possible at HAS given the absence of an onsite pathologist. At the time of this report a commercially available serologic test was not available, and PCR is not feasible at this rural hospital. At HAS most physicians are confident in making the diagnosis of cutaneous anthrax on the basis of the WHO clinical criteria. However, unusual cases of cutaneous anthrax and cases of intestinal anthrax or inhalation anthrax without cutaneous manifestations may go undetected without laboratory diagnostics.

Our case control study is limited by the number and matching of controls. This limited the detail and the number of associations that could be made between animal and butchering practices and risk for anthrax. Our case control study was conducted by physicians to promptly guide the public health response to the growing number of cases of anthrax seen at the hospital. Although limited, it provided critical information that confirmed prior suspicions of the etiology of this cutaneous anthrax epidemic.

In conclusion, the number of cases of anthrax in the Artibonite Valley has increased by 20-fold in the past 10 years. Anthrax is a cause of significant morbidity and mortality and is related to butchering and handling meat from cattle or goats that had died of illness. We believe that the evidence presented in this report is sufficient to prompt further public health investigations and animal health interventions including livestock anthrax vaccination programs. We hope that international agencies will work together with the Haitian government in these efforts.

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We have no conflicts of interest to report.

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REFERENCES


