

The cause of the plague of Athens: plague, typhoid, typhus, smallpox, or measles?

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A Dorian War will come, and with it a Plague

Ancient Greek proverb

The cities of Athens and Sparta were rivals in ancient Greece. The power of Athens was based on its large navy, which gave the government maritime supremacy and control of commercial sea lanes. The wealth of Athens depended on maritime supremacy and commercial relationships along the Mediterranean and Aegean littoral. Sparta was land based, and its power depended on its army. The warriors from Sparta were the finest land army at that time in the ancient world. The rivalry between Athens and Sparta eventuated in the Peloponnesian War, which broke out in 431 BC. The Peloponnesian War lasted 27 years and was responsible for the downfall of Athens and the end of the Periclean golden age of Greek culture. The outcome of the Peloponnesian War largely was determined by the failure of the Athenians to conquer Sicily in 415 BC and by the plague that ravaged Athens in 430 BC. After the Athenian fleet was destroyed, as a result of the failed attempt to invade Sicily, Athens was forced to defend itself in a land battle that the city tried to avoid.

The Athenians had a small land army and were no match for the Spartans in open land combat. The Athenians concentrated in Athens and built walls to provide a protected conduit to Piraeus, the main port of Athens. As the Peloponnesian War progressed, Athenians living in the countryside came to Athens to avoid the advancing Spartans. Within the city and within the walled conduit leading to Piraeus, the population became crowded into confined quarters, setting the stage for a variety of infectious diseases associated with crowded conditions. The plague of Athens began 1 year after the war started, and the epidemic continued in southern Greece for 4 years. According to Thucydides, approximately one quarter of the Athenian army perished as a result of the plague. Approximately one quarter of the civilian population of southern Greece

was ravaged by the plague during its 4-year rampage. Pericles himself succumbed to the Plague, which was symbolic of the end of the classical age in ancient Greece. The 27-year war divided and destroyed Greece as a power in the ancient world. Drained of resources in a population decimated by war and plague, Greece was not able to recover and regain its preeminence in the ancient world [1–3].

Possible causes of the plague of Athens

The infectious disease that caused the plague of Athens has been the topic of discussion among classical scholars and physicians for centuries, and the debate continues. Various infectious diseases have been proposed as the cause of the plague of Athens, and there is no consensus among classical scholars or physicians even regarding the most likely plausible explanation. The most common infectious disease causes mentioned in discussions regarding the plague of Athens include bubonic plague, influenza, typhoid fever, smallpox, epidemic typhus, and measles. All of these infectious diseases are contagious and potentially lethal [4–6].

The reason for the lack of general agreement on the cause is the lack of definitive microbiologic proof in the absence of paleopathologic evidence and in differences in scholarly perspective. The two groups of academics that have been concerned about determining the cause of the plague of Athens are classical scholars and physicians. Classical scholars emphasize interpretational problems with Thucydides' description of the plague and are less able to evaluate the medical aspects of Thucydides' description. Investigators in the medical community, most of whom are not intimately familiar with the nuances of ancient Greek, are at the mercy of translators' descriptions of medical terms with which translators are not familiar. Physicians offer a discussion of differential diagnostic possibilities but are limited by the various interpretations of nonmedical terms with medical meaning in Thucydides' text. Few infectious disease clinicians have tried to determine the cause of the plague of Athens, even though they are in the best position to evaluate the various aspects of the most likely infectious disease diagnoses. This article is an attempt by an infectious disease clinician to use the best possible translations of ancient Greek by classical scholars, taking into account the various interpretations of critical words in Thucydides' description. The most likely cause for the plague of Athens should depend on a careful analysis of the key features of the most likely infectious disease possibilities that have been entertained. In differential diagnosis, all signs and symptoms do not have equal diagnostic weight. Key features of various infectious diseases that are highly characteristic of the infection have more clinical importance and specificity than those that are simply compatible with a particular infectious disease. This article reviews the most likely infectious disease entities responsible for the plague of

Athens, using the best translations of ancient Greek available and a differential diagnostic approach based on weighted diagnostic possibilities [7–10].

Terminology in Thucydides' description of the plague

In the absence of direct microbiologic evidence, the analysis of the plague must be approached from a linguistic perspective, an epidemiologic approach, or a clinical perspective. Thucydides was not a physician but was a careful observer and recorder of events. His description of the plague of Athens is critical, because it is the only extant description of the plague; any attempt to determine the infectious disease agent responsible for this plague must depend on his choice of descriptive terms and his powers of observation. Thucydides himself had the plague, so he had first-hand knowledge of its signs and symptoms and was able to observe its effects in people around him. Thucydides' choice of words reflects his familiarity with the medical terms used by physicians of ancient Greece to describe various maladies. The word "plague" had many meanings for the ancients and did not necessarily refer to bubonic plague, but rather was a general term for a severe or widespread pestilence. Thucydides carefully chose his words and did not include features that were not present and did not exclude important features that were present. The word for "rash" in ancient Greek has been interpreted in many ways and ranges from blisters or pox, to ulcers or sores, to an exanthem. Thucydides was limited by the descriptive terms used in ancient Greek medicine and applied them as accurately as possible with the precision of an historian, a keen observer, and a victim. For these reasons, it is certain that key features of the plague in Athens were not omitted or overlooked by Thucydides, and every essential feature was described in the best possible terminology in use at the time, subject to various interpretations. Some terms used today still are open to interpretation (eg, yellow jaundice, which describes the skin discoloration of an individual but is unhelpful as to cause) [2,4,10–12].

Epidemiologic considerations

For an infectious disease to be considered as a likely cause of the plague of Athens, it must have existed at the time. It is difficult to find paleopathologic evidence of infectious diseases that are acute and fulminant and leave no recognizable changes in organs that are preserved over time. Bone and skin changes are the two organ systems that are likely to have survived through the ages with evidence of pathognomonic changes ascribable to a particular disorder. The causative agent of the plague of Athens killed rapidly, affecting all age groups. Predictably, little or no

physical evidence would be able to survive that would provide clues to the cause of the plague. Only from descriptions and writings of ancient physicians can we infer the presence of various infectious diseases in antiquity. Infectious diarrheas and dysentery, as described by the ancients, imply that typhoid fever was an endemic problem in the ancient world. Similarly, malaria existed in ancient Greece. Smallpox and measles probably existed in antiquity, but accurate descriptions of these infections do not appear in the medical literature until later epochs. The presence of the bubonic plague in ancient Greece depends on the demonstration that black rats were in the area and able to transmit, by way of rat fleas, bubonic or pneumonic plague to Athenians. If the presence of black rats in ancient Athens cannot be inferred, the likelihood of bubonic plague causing the epidemic is diminished greatly. Other animals (ie, goats) also may be plague vectors. Similarly, if typhus is entertained as a diagnostic possibility for the plague of Athens, lice would have to have been present at the time. Personal hygiene and clothing habits may have been altered during the siege of Athens by the Spartans, but the presence of lice could be inferred by descriptions of intense pruritus in the nonaffected population of ancient Athens. It would seem that epidemiologic evidence is most useful in decreasing the likelihood of diagnostic possibilities, but ultimately the problem is best approached by an analysis of the clinical findings as described by Thucydides [13–15].

Clinical considerations and diagnostic reasoning

In differential diagnosis, particularly of infectious diseases, certain findings have more diagnostic significance than others. There is a crucial difference between findings that are compatible with a particular diagnosis and those that are characteristic of the diagnosis. Legionnaires' disease regularly involves the liver, as manifested by mild or transient elevations of serum transaminase levels. These symptoms are so highly characteristic of Legionnaires' disease that they may be used to differentiate Legionnaires' disease from *Mycoplasma*-related pneumonia, in which liver involvement rarely is part of the clinical presentation. The presence of slightly increased serum transaminase levels in a patient with an atypical pneumonia is an important diagnostic finding [8]. In Thucydides' description, the key diagnostic findings characteristic of certain infectious diseases have more diagnostic weight than less specific findings. He mentions that patients had a livid red rash that began from the head and descended to the feet. Few infectious diseases have an intensely red rash, even given the interpretational problems of rash. Does Thucydides mean blister, sore, pox, or ulcer? Is he using a generalized term for an exanthem? Even after allowing for variable clinical presentation, it is highly unlikely that typhoid fever, with its few and faint rose spots, could be considered as to be consistent with Thucydides'

description of the rash. Thucydides carefully described the rash as beginning with the head and moving toward the feet. This finding is highly characteristic of measles and is a symptom in a few other infectious diseases [10]. Although smallpox starts at the hairline and proceeds to the extremities, it is not accompanied by the intense lividity described by Thucydides. The rash of hemorrhagic smallpox characteristically begins in the groins and thighs, not from the head down. The rash of typhus is truncal and does not characteristically progress from the head to the lower extremities. The rash of typhus also does not have the intense lividity noted by Thucydides. Even if the word for “rash” has been misinterpreted and actually signifies blisters or ulcers, which may be buboes, the rash seems to be in the wrong anatomic location (ie, it is not in the axilla or groin), and an intense rash, particularly progressing from the head to the extremities, is not a feature of bubonic or pneumonic plague [16,17]. Key findings in infectious diseases also have important exclusionary value if they are not present. Given that patients with hemorrhagic smallpox may die in 3 or days before poxes become manifest, it is hard consider smallpox to be the cause when Thucydides makes no reference to pox per se. Thucydides mentions that survivors had immunity to a subsequent attack. If smallpox were responsible for the plague of Athens, one reasonably would assume that poxes would be present in some of the survivors and would have been noted by Thucydides. Poxes are conspicuous by their absence in his description, and such absence argues strongly against the possibility of smallpox as the cause of the plague [18]. Each diagnostic possibility is discussed from an epidemiologic and clinical perspective based on the best available translations of Thucydides [6,8,19,20].

Thucydides’ description of the great plague of Athens

It was generally agreed, that in respect of other ailments no season had ever been so healthy. Previous diseases all turned off into the plague; and the rest of the people were attacked without exciting cause, and *without warning, in perfect health*. It began with violent sensations of heat in the head, and *redness and burning in the eyes*; internally, the *throat and tongue were blood-red from the start*, emitting an abnormal and *malodorous breath*. These symptoms developed *into sneezing and hoarseness*, and before long the trouble descended into the chest, attended by *violent coughing*. Whenever it settled in the heart, it upset it, and evacuations of bile ensued, of every kind for which the doctors have a name; these also together with great distress. Most patients suffered an attack of *empty retching, inducing violent convulsions*, in some cases soon after the abatement of the previous symptoms, in others much later. The *body was neither unduly hot externally to the touch, nor yellowish in colour, but flushed and livid*, with an efflorescence of *small blisters and sores*. *Internally, the heat was so intense that the victims could not endure the laying-on of even the lightest wraps and*

linens; indeed nothing would suffice but they must go naked, *and a plunge into cold water would give the greatest relief. Many who were left unattended actually did this, jumping into wells*, so unquenchable was the *thirst* which possessed them; but it was all the same, whether they drank much or little. The victims were attacked throughout by inability to rest and by *sleeplessness. Throughout the height of the disease the body would not waste away* but would hold out against the distress beyond all expectation. The *majority succumbed to the internal heat before their strength was entirely exhausted, on the seventh or ninth day*. Or else, *if they survived, the plague would descend to the bowels*, where severe lesions would form, *together with an attack of uniformly fluid diarrhoea* which in most cases ended in *death through exhaustion*. Thus the malady which *first settle in the head passed through the whole body, starting at the top*. And if the patient recovered from the worst effects, symptoms appeared in the form of a seizure of the extremities: the *privy parts and the tips of the fingers and toes were attacked*, and many survived with the loss of these, others with the *loss of their eyes*. Some rose from their beds with a total and *immediate loss of memory*, unable to recall their own names or to recognize their next of kin [10].

Key clinical features of the plague in Thucydides' description

Given the difficulties of translation and interpretation, Thucydides' description is as careful and complete as one might expect from the written record in antiquity. The key clinical findings according to Thucydides include an acute infectious disease characterized by rapid onset and fever. Frank shaking chills are not included in his description. Early features described by Thucydides include red eyes (eg, conjunctival suffusion), runny nose and sneezing (eg, catarrh), and a red throat and hoarseness (eg, pharyngitis accompanied by foul breath). Subsequently, the patients with plague developed a livid red rash that proceeded from the face to the trunk and finally to the extremities. Blisters and sores are mentioned, but it is not clear whether these symptoms are part of the rash or a distinctive clinical feature. The sensation of intense internal heat experienced by the patients is described clearly. Thucydides commented that although the patients did not feel warm to the touch, the sensation of internal heat was so profound as to cause some patients to seek relief by jumping into rivers or streams. Sleeplessness and diarrhea were described late in the course of the illness. Thucydides described the patients as remaining healthy until they died of exhaustion, usually by day 7 to day 9. Some survivors developed body or extremity gangrene, loss of sight, or loss of memory (Table 1) [7,10].

The critical question is what sort of infectious disease presents in this fashion and is characterized by the clinical features described by Thucydides. Was the plague of Athens caused by a previously undescribed infection? Severe acute respiratory syndrome originated in China and spread worldwide. It is an example of a modern plague that to the best of current

Table 1

Key clinical features of the plague of Athens in Thucydides' description

Clinical description	Time appearance
Rapid onset	Early
Fever	Early
Red eyes	Early
Runny nose, sneezing	Early
Red throat, hoarseness	Early
Foul breath	Early
Retching, convulsions	Middle
Livid red rash ^a	Middle
Blisters, sores	Middle
Sensation of intense internal heat	Middle
Sleeplessness	Late
Diarrhea	Late
Body or extremity gangrene	Late
Loss of sight	Late
Loss of memory	Late
Healthy until death by exhaustion	Late

^a Face → extremities.

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Class Q* 1953;3:97–119; with permission.

knowledge did not exist in humans but may have existed for a long time as zoonoses. Was the plague of Athens caused by an infectious disease that had been known since antiquity, changed in nature over the centuries, and had unique clinical features that are unrecognizable in the present era? The virulence of infectious diseases varies among populations and over time as the populations is subjected repeatedly to subsequent attacks of the infection [13,15].

Because Thucydides is such a careful observer and used the medical terminology available to him at the time, it seems reasonable to assume that no key clinical features were omitted and that his description is as accurate as was possible at the time. Thucydides remarked that survivors had immunity to subsequent attacks; the plague of Athens raged for years after the initial plague described Thucydides. The theory that the plague was caused by an infectious disease that never was seen before and is not present now seems unreasonable, because most clinical features in Thucydides' description are cardinal findings in infectious diseases that have existed until recent times. Given variations in severity and clinical manifestations as occurred in ancient Athens, Thucydides supplied a fairly accurate description of an acute infectious disease, which had features of infectious diseases still recognizable at the present time. The plague described by Boccaccio, which came from Africa, began in Sicily, and spread to Italy and then throughout Europe, was the bubonic plague. The descriptions of bubonic plague are different than Thucydides' description of the infection that decimated Athens during the Peloponnesian War. Using Thucydides'

description, I try to arrive at the most probable clinical diagnosis based on epidemiologic and clinical considerations [16,21,22].

Bubonic plague

Many European authors described a plague that was an infectious disease, which was probably bubonic or pneumonic plague. The descriptions of bubonic plague in Europe are internally consistent, and all of them describe the same clinical infectious disease (eg, bubonic or pneumonic plague). European descriptions of plague closely resemble each other, but they are different from Thucydides' description (Table 2) [23–27].

The only features consistent with bubonic plague in Thucydides' description are the rapid onset of the infection accompanied by fever with dry cough. The blisters and ulcers described by Thucydides may have represented the buboes of bubonic plague; however, a careful observer like Thucydides would have mentioned their presence in the axilla or in the groins, which he does not. Thucydides is too careful of an observer to have omitted this major feature of bubonic plague. Many features argue against the bubonic or pneumonic plague as being the cause of the epidemic in ancient Athens. These plagues do not begin on the head, and the upper respiratory symptoms described by Thucydides are not features of the plague. The important reference to the sensation of intense internal heat is not a feature of these plagues. Diarrhea, loss of sight, and loss of memory are rarely features of bubonic plagues. The absence of the location and nature of buboes is a strong argument against bubonic plague. On epidemiologic grounds, the bubonic plague is difficult to consider in the

Table 2
Key features of the plague in Thucydides' description

Features present	Features not present
Fever	Begins on head
Rapid onset	Runny nose, sneezing
Dry cough (pneumonic plague only)	Red throat, hoarseness
Blisters or ulcers	Livid red rash
	Sensation of intense internal heat
	Foul breath
	Retching, convulsions
	Diarrhea
	Buboes
	Sleeplessness
	Loss of sight
	Extremity gangrene
	Loss of memory

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Classic Q* 1953;3:97–119.

absence of black rats. Transmission of the plague by rat fleas from black rats is a necessary prerequisite for an epidemic of bubonic plague. Thucydides and other Greek writers of the time make no mention of black rats. There is not a word in ancient Greek for “rat.” A careful observer like Thucydides would have noticed black rats alive and dead in considerable numbers. Even if he did not appreciate the causal relationship between black rats and the plague, it seems unlikely that he would not mention black rats being present during the epidemic. On epidemiologic and clinical grounds, bubonic or pneumonic plague does not fit well with Thucydides’ description and is an unlikely cause of the plague of Athens [7,10,13,28].

Typhoid fever

There is no question that typhoid fever existed in ancient Greece. Hippocrates described diarrheal illnesses as one of the major health problems when he wrote his famous aphorisms. Typhoid fever requires fecal contamination of water and subsequent contamination by water or food containing *Salmonella typhi*. Few features suggest that typhoid fever was the cause of the plague of Athens. Fever and diarrhea are the only two key clinical features consistent with a diagnosis of enteric fever. The rash described by Thucydides has no resemblance to rose spots in location, intensity or progression with the infectious disease epidemic in Athens. More than a dozen features described by Thucydides are inconsistent with the diagnosis of typhoid fever, even after allowing for interpretational variation. Deaths from typhoid fever occurred 2 to 3 weeks into the illness and were caused by intestinal perforation and subsequent peritonitis or intestinal hemorrhage and exsanguination. Deaths from typhoid fever usually occurred 2 to 3 weeks after the illness, which is much later than the time that victims of Athens were dying from their acute infectious illness. Typhoid fever does not confer good immunity to subsequent attacks, which is a point made by Thucydides. Although typhoid fever is occasionally fatal when complicated by peritonitis or intestinal hemorrhage, it is hard to conceive of typhoid fever eliminating a quarter of the population in short order. Typhoid fever is usually subacute in onset, and patients are anything but healthy until their ultimate demise, which is in direct contrast to what Thucydides describes in the victims of the plague. Typhoid fever is a most unlikely explanation for the cause of the plague of Athens (Table 3) [2,4,7,29].

Epidemic typhus

Epidemic typhus has been mentioned as a possible explanation for the plague of Athens. This disease is rapid in onset and is characterized by fever, conjunctival suffusion, and truncal rash. Complications include extremity

Table 3
Key features of typhoid fever in Thucydides' description

Features present	Features not present
Fever	Rapid onset
Diarrhea	Red eyes
Rash (rose spots)	Runny nose, sneezing
	Red throat, hoarseness
	Foul breath
	Retching, convulsions
	Sensation of intense internal heat
	Livid red rash
	Sleeplessness
	Extremity gangrene
	Blisters, sores
	Death from intestinal perforation or hemorrhage in 2 to 3 weeks

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Classic Q* 1953;3:97–119.

gangrene. McCarther described cases of typhus in which the sensation of internal heat was so intense that the patients immersed themselves in water for relief. Loss of vision is a rare complication of typhus [13,29].

These features are mentioned prominently in Thucydides' description of the plague. Against the diagnosis of epidemic typhus is the lack of upper respiratory symptoms, particularly the runny nose, sneezing, foul breath, and dry cough. The internal sensation of heat would be unusual in epidemic typhus. Diarrhea is not part of the clinical syndrome, nor is death by exhaustion. Epidemic typhus needs black rats for transmission of typhus by way of body louse. The rash of typhus is truncal and does not progress from the head to the extremities as described by Thucydides. Neurologic symptoms, deafness, difficulties with recall, and delirium may occur before death or may persist in survivors. The immunity against typhus caused by *Rickettsia prowazekii* is incomplete and is manifested clinically by recrudescent mild typhus (eg, Brill-Zinsser disease). The descriptions of typhus epidemics in Italy from the 16th century describe a petechial fever characterized by headache and malaise, which differs fundamentally from the infectious disease described by Thucydides. Although epidemic typhus is a more likely possibility than typhoid fever or bubonic plague, it does not, in my opinion, have enough key clinical characteristics to make it the most likely diagnostic possibility as the cause of the plague of Athens (Table 4) [2,4,10,14,29].

Smallpox

Smallpox is one of the most popularly mentioned causes of the plague of Athens. Although there is no consensus among classical scholars or clinicians, smallpox is a leading contender for the cause. Thucydides'

Table 4

Key features of epidemic typhus in Thucydides' description

Features present	Features not present
Fever	Evidence of black rats, lice
Rapid onset	Red throat, hoarseness
Red eyes	Foul breath
Hoarseness	Dry cough
Rash (truncal)	Runny nose, sneezing
Body or extremity gangrene	Blisters, sores
	Internal sensation of heat
	Retching, convulsions
	Diarrhea
	Sleeplessness
	Loss of sight
	Memory loss
	Death by exhaustion

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Classic Q* 1953;3:97–119.

description has many features that are consistent with smallpox features, particularly rapid onset, fever, eye involvement, and rash. The blisters and sores mentioned could represent the vesicles of smallpox. The intense sensation of internal heat has been mentioned in smallpox epidemics and is consistent but is not characteristic of smallpox. Extremity gangrene may occur in survivors of smallpox. Smallpox frequently is complicated by blindness. Loss of memory is not characteristic of smallpox.

Smallpox has many varieties; as a cause of the plague of Athens, conventional smallpox and hemorrhagic smallpox are the clinical forms that would best explain a smallpox epidemic of the magnitude described by Thucydides [30,31]. Assuming that conventional smallpox was responsible for the epidemic, the lack of certain features in Thucydides' description is noteworthy. Smallpox regularly is accompanied by a severe headache or backache. Even if Thucydides did not experience these symptoms as a plague victim, he would have noticed them in most individuals with the plague. Other features mentioned by Thucydides are not consistent or characteristic of smallpox. Death by exhaustion after remaining relatively healthy until death does not sound like smallpox. A noteworthy omission in Thucydides' description is the absence of pox. It seems highly unlikely that Thucydides' term for blisters or sores described smallpox vesicles. The blotchy red rash proceeding from cephalad to caudad argues strongly against the diagnosis of smallpox. Smallpox vesicles first appear as macules at the hairline and proceed downward from the face, which is profoundly different than the rash beginning on the face as described by Thucydides [2,10,20,31].

If it is assumed that the Athenians had hemorrhagic smallpox, also known as hypertoxic smallpox, they would not have developed vesicles (ie, poxes). Hemorrhagic smallpox begins abruptly with fever, facial swelling,

and a petechial rash during the prodromal period. The rash of hemorrhagic smallpox that appears during the prodromal period may resemble measles (eg, measly or morbilliform) or scarlet fever (eg, scarlatina form) or may be petechial or purpuric. The petechial or purpuric rashes during the prodromal period precede the subsequent rash of hemorrhagic smallpox. The petechial prodromal rash in smallpox begins in a swimming-trunks distribution, beginning in the groin and thighs and extending to the trunk and extremities. Hemorrhagic smallpox proceeds so rapidly that the toxemia from the intense viremia often kills the patient before poxes have time to develop [30,31]. If the plague of Athens was caused by hemorrhagic smallpox, Thucydides was correct in not citing poxes, because poxes are not present in hemorrhagic smallpox. Hemorrhagic smallpox was uniformly fatal. It would be hard to conceive of a smallpox epidemic that was exclusively of the hemorrhagic variety. Even in a highly lethal smallpox epidemic, at least some survivors would have had poxes readily visible and describable by Thucydides [18]. His description of blisters or sores without reference to specific anatomic location leaves the diagnosis of smallpox open to question. Consistent with the diagnosis of smallpox is the fact that survivors were immune to subsequent attack in the years after the initial epidemic, as noted by Thucydides [2,20,32].

Hemorrhagic smallpox differs considerably from conventional smallpox and its clinical manifestations. Hemorrhagic smallpox occurs in a minority of patients in a smallpox epidemic, but is the most lethal form of smallpox. A combination of hemorrhagic and conventional smallpox is a better explanation for the plague of Athens than is typhoid fever or epidemic typhus. Smallpox has many key features as described by Thucydides, including loss of vision and extremity gangrene [20,31]. Blister or sores have convinced most non-infectious disease clinicians that the plague of Athens was caused by smallpox. Even if it is assumed that Thucydides was describing smallpox vesicles, the red blotchy rash proceeding from head to foot, which is incompatible with hemorrhagic and conventional smallpox. The lack of poxes in Greek statues or mention by other writers argues strongly against smallpox as being responsible for the plague of Athens (Table 5) [18,31].

Measles

Measles is not believed to be a highly fatal disease today; however, epidemic measles in nonimmune populations has resulted in a mortality rate of up to 25%. The description of measles in such populations bears a striking resemblance to the epidemic in ancient Athens. Measles now is considered to be a disease of children, because adults have been exposed to measles or have been immunized. In a nonimmune population, all ages are affected, but measles is particularly severe in the adult population. The Fiji Island

Table 5
Key features of smallpox in Thucydides' description

Features present	Features not present
Fever	Back or loin pain
Rapid onset	Pox
Red eyes	Runny nose, sneezing
Livid red rash (hemorrhagic smallpox rash in thighs, groin)	Foul breath
Blisters, sores	Diarrhea
Intense sensation of internal heat	Loss of sight
Body or extremity gangrene	Sleeplessness
Loss of sight	Loss of memory
	Death by exhaustion

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Classic Q* 1953;3:97–119.

experience with measles was associated with high mortality and morbidity rates and was followed by outbreaks across the South Pacific that decimated the population of this area. Characteristic of measles in nonimmune individuals is its acute onset and blotchy red morbilliform rash that begins on the face and proceeds downward. Early in the infection, upper respiratory tract involvement is prominent and characterized by conjunctival suffusion, runny nose, and hyperemic and intensely red buccal mucosa. Foul breath has been described as accompanying early measles. A dry cough occurs as the distal respiratory epithelium is infected by measles. In the Fiji Island outbreak, there was particular reference to the intense sensation of internal heat also mentioned by Thucydides. This feature was prominent in the Fiji Island epidemic. Victims of the Fiji Island epidemic ran to streams and rivers to relieve the sensation of heat, and victims of ancient Athens jumped into wells for relief. This finding is fairly specific. The high mortality rate in the Fiji Islands (approximately 25%) was not entirely caused by the virulence of measles. As most of the population became ill, most deaths occurred from exhaustion and starvation. Adults were not able to harvest, prepare, or distribute food. Patients died within 2 weeks of infection as a result of measles combined with inadequate fluid and food intake. Thucydides' description of the lividity of the rash and its progression from the head to the extremities is characteristic of measles. Particularly vivid are Thucydides' description of the red eyes, runny nose, and red throat of the Athenian victims, which is highly characteristic of measles [2,10,13].

Against the diagnosis of measles is the lack of sores or blisters mentioned by Thucydides. The words used for sores and blisters are subject to interpretational variation and could represent the nonvesicular maculopapular rash of measles. Extremity gangrene and diarrhea are not features of measles. Measles may be accompanied by interstitial pneumonia, accounting for the cough described by Thucydides, and by encephalitis, accounting for the memory loss, delirium, and convulsions described. The strongest

Table 6
Key features of measles in Thucydides' description

Features present	Features not present
Fever	Retching, convulsions
Acute onset	Sores, blisters
Livid red rash	Memory loss
Red eyes	Diarrhea
Runny nose, sneezing	Extremity gangrene (rare)
Red throat, hoarseness	Loss of sight
Foul breath	
Dry cough	
Intense sensation of internal heat	
Sleeplessness, restlessness	
Death by exhaustion	

Adapted from Page DL. Thucydides' description of the great plague of Athens. *Classic Q* 1953;3:97–119.

argument against measles is the lack of diarrhea and extremity gangrene (Table 6) [2,10,29].

Summary

A clinical diagnosis based on Thucydides' description must of necessity be an analysis based on clinical features of each diagnostic possibility. I have used key clinical findings, which are not only consistent but are characteristic for each infectious disease considered to be a probable cause of the plague. Smallpox or measles best explains what happened in Athens early in the Peloponnesian War.

Once clinical remains are tested for typhus, smallpox, and measles using DNA probe technology, pelopathologic evidence will continue the debate about the cause of plague. Until such proof is available, the preponderance of characteristic clinical features favors measles as the best explanation for the plague of Athens.

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