

Chapter X

DIAGNOSIS OF GAS BACILLUS INFECTION

In some regions of this country, few cases of gas bacillus infection are encountered, but in the areas where they do occur the importance of early and correct diagnosis is well appreciated. To those who have had no experience with the disease, early and correct diagnosis cannot be overemphasized; this was well stated by Graham.

the disease is fully developed there is no difficulty, but it is frequently useless as far as the patient is concerned. The situation becomes irretrievable very rapidly so that diagnosis and treatment must be prompt and conclusive.⁴

The diagnosis may be based on several symptoms and findings which are more or less acceptable but occasionally are open to question. Owing to the fulminating character of the infection, one is eager to make the diagnosis as early as possible, before the late stage is reached, and this desire sometimes leads to diagnosis from very few data. For this reason the criteria on which one may be justified in making a diagnosis in a suspicious, early or late case are considered in the following discussion.

IMPORTANCE OF EARLY DIAGNOSIS

We seldom see a fully developed toxic case of gas gangrene unless the patient is brought in from the country in that condition. There are, however, exceptions to any rule, and gas infection in a patient after a hypodermic injection is a case which breaks most of the rules. The lesson to be drawn from the early death of most of the patients in this group is the importance of early diagnosis and early treatment.

One patient (Case 11) received a hypodermic injection one evening and was admitted to the hospital the following day about 11 A. M. Therapeutic doses of tetanus and perfringens antitoxin were given and numerous puncture wounds and incisions were made into the involved tissues of the thigh, gluteal and lumbar regions which were irrigated with oxidizing solu-

tions. About one o'clock he was also given x-ray therapy to all of the involved and adjacent tissues. He died during the afternoon.

The entire course was less than 24 hours, and from a therapeutic standpoint nothing was omitted. No discussion of the importance of diagnosis of gas bacillus infection is complete without reference to those cases which follow the administration of a hypodermic injection.

The short but fatal course of this patient's infection is char-

reports of similar cases in the literature, it is obvious that such a patient dies so quickly that little can be done for him unless the diagnosis is made at the very inception of the disease and treatment started accordingly.

If any clinician witnesses the quick death which occurs in such cases, he will ever after be less resistant to the early use of an x-ray film to determine the presence of gas, and he will no longer argue that a small amount of gas in the tissues is there as a result of the accident, not because of the presence of a gas-forming organism, or that it is not important and so will wait to see what develops. He will understand the eagerness of the radiologist to start treatment early on patients who have a deeply situated collection of gas in the tissues. Uncertainty as to the mode of entry or cause of gas in the tissues should not deter one from starting x-ray treatment immediately. If the collection of gas is innocent or nonpathogenic, no harm will have been done, and if it is the early stage of a serious infection, much good will have been done.

STAGES OF THE DISEASE

1. In the suspected stage are listed certain symptoms and findings commonly found at the beginning of the disease. They constitute the criteria for diagnosis in the suspected stage and may disappear entirely when x-rays are administered. They may disappear when no treatment is given, or they may increase in severity into a fully developed early stage of the disease. This simply means that during the suspected stage they form a group of symptoms and signs which may or may not mean the beginning of an active gas bacillus infection.

2. In the early stage, essentially the same findings and symptoms are seen as in the suspected stage but differ in intensity. This difference, permitting a positive diagnosis, may be only a matter of a few hours from the time the case was considered to be in a suspected stage.

3. The late stage has all the symptoms and findings of the suspected and early stages, but with increased severity. In addition, other cardinal symptoms such as the characteristic odor and the gangrenous tissue appear.

The essential difference on which opinions are formed in placing cases in the different stages of the disease, therefore, rests entirely on the severity of the symptoms or the extent of the findings.

Suspected Stage.—The appearance of a small amount of gas in the damaged tissues or the demonstration of organisms on smears is not absolute evidence that the patient has or will develop a gas bacillus infection in its true clinical sense. Inclusion of such cases in any series of gas bacillus infection cures is always open to question, since admittedly some of these findings may be present and the patient may recover when no treatment for gas bacillus infection has been undertaken. Such occurrences are rare, and in the opinion of the writers and many others, these findings, when they complicate a trauma, severe or even minor, should be considered evidence of early gas bacillus infection and treatment should be instituted accordingly.

When gas or organisms appear in an area of primary gangrene or other necrotic tissue, which often happens prior to surgical removal of dead tissue, their presence is undoubtedly not as serious as are gas and organisms in recently damaged tissues. The suspected case might be described as one in which a gas bacillus infection often develops. In the wound there may be evidence of superficial pockets of gas, or gas-forming organisms may be demonstrated on smear by the laboratory. But the disease is not spreading rapidly and the patient does not show evidences of active local invasion or of general toxemia.

Early Stage.—In more advanced stages of the infection, diagnosis may be based on the findings in the suspected stage plus evidence of some of the gas-forming organisms in culture and signs of extension of the disease. Gas may or may not be palpable in the tissues, but usually at this stage it is demonstrable

on the x-ray film and is spreading. The earliest diagnosis of the condition is best made by x-ray study of the infected area, showing gas in the deeper tissues even before it has time to reach the surface of the wound, cause toxic symptoms or become palpable. The x-ray film is therefore the most important aid in making an early diagnosis.

Diagnosis should be made before evidences of toxemia are present, if it is at all possible to do so. Pain is an important early symptom; unexplained pain or pain out of proportion to the extent of the injury or the character of the hypodermic injection calls for an immediate x-ray examination for gas in the deeper tissues. Presence of gas in such circumstances is of major diagnostic significance.

If doubt still exists, a film taken three to five hours later may show an extension of the gas in the tissues; if so, the diagnosis is certain.

Late Stage.—Any clinician with experience has no difficulty in the diagnosis of a case in the late stage. In the late stage the following symptoms and findings are present: odor, which often reaches you before you reach the patient; locally, often a foul discharge and probably some gas escaping from the tissues which are discolored, swollen and may be truly gangrenous; gas often palpable in the tissues and always demonstrable on the x-ray film. The patient is usually toxic in this stage, has fever, increased pulse and respiratory rates and obvious prostration, and he may be delirious or comatose. The white blood cell count is generally high. A mixed infection is present, and the laboratory is able to demonstrate on smear and in culture one or more of the anaerobes usually found.

X-RAY STUDY IN DIAGNOSIS

X-ray films in diagnosis of gas bacillus infection are not used as generally or appreciated as thoroughly as they should be. The demonstration of an increasing amount (in a few hours) of gas in the damaged tissues is positive evidence of an active gas bacillus infection.

X-ray examination should be routine procedure following severe injuries likely to be complicated by a gas bacillus infection. Hickey¹⁶ made first reference to the method, as far as we

are able to determine. Knox¹⁵ described the use of this method in 1917. Rhinehart¹⁷ made an excellent report on this phase of the subject in 1933. Kenning¹⁸ has used this method of diagnosis for many years so that appropriate measures might be taken to treat the disease at its first appearance.

Gas in the tissues demonstrable on the x-ray film is usually the first finding, and *pain* is usually the first symptom. The production of gas is followed by an increased discharge, which is usually serosanguineous and has a foul odor. By this time, gas may be felt in the tissues which are considerably swollen and

The recent claim that a positive culture of the organism in the wound is diagnostic of gas bacillus infection and can be ascertained before gas can be demonstrated in the deeper tissues by means of an x-ray film is of no clinical significance. The presence of organisms does not mean an active gas bacillus infection, and the presence of gas in the tissues is not necessarily positive evidence that a gas bacillus infection is present. X-ray films taken at intervals, as advocated by Kenning and others, are much more significant than early bacteriologic studies. To make an absolute diagnosis which will be correct on every occasion for the earliest stages of gas bacillus infection will remain a difficult problem. Prompt use of x-ray therapy during this early doubtful stage of the disease will forestall future concern.

DIAGNOSTIC CRITERIA

In Table 4 are listed the diagnostic criteria according to their importance as they appear during the progress of the disease. It is not necessary that all of these findings be present before a positive diagnosis is made, and some combinations may be present and still a positive diagnosis is not warranted.

With an infection which progresses as rapidly as gas bacillus infection, a case in the suspected stage may in a few hours become one in the late stage. Therefore one should not depend too much on any suggested division into clinical stages. For purposes of discussing the problem and to make allowance for an occasional case, it may be of some value to separate the disease into stages even if the dividing line is not sharp and the

TABLE 4
CRITERIA FOR DIAGNOSIS OF GAS BACILLUS (GAS GANGRENE) INFECTION*

CRITERIA WARRANTING PROPHYLACTIC MEASURES	CRITERIA FOR DIAGNOSIS OF VARIOUS STAGES			
	Symptoms and Findings	Stages		
		Suspected	Early	Late
1. Penetrating or lacerated wound which may be infected 2. Usually, any injury warranting tetanus antitoxin should receive x-ray prophylaxis for gas infection 3. After any operation for removal of area of primary gangrene or other necrotic tissue which may harbor gas organisms or spores 4. After any secondary surgical repair in an area recently recovered from gas infection 5. After any hypodermic injection which causes unusual pain, x-ray film should be taken; if gas is demonstrable in tissues, immediate treatment should be started; if in doubt, a prophylactic dose may be used	1. Obviously infected penetrating or lacerated wound.	+	+	+
	2. Swelling of tissues			
	At site of injury.....	+	+	+
	Distant from injury.....			+
	3. Discoloration of tissues			
	At site of injury.....	+	+
	Distant from injury.....		+	+
	4. Presence of organisms			
	On smear.....	+	+	+
	On culture.....		+	+
	5. Discharge (serosanguineous).....	+	+	+
	6. Gas in tissues			
	On the film			
	a) little near wound, not increasing.....	+
	b) extensive, spreading, rapidly increasing.....	+	+
On palpation, crepitation.....	.....	+	+
On inspection, escaping from wound.....	.....	.....	+
7. Pain				
Slight, superficial, local.	±†	+	.....
Unexplained, severe, deep, referred.....	.....	±	+
8. Elevation of pulse				
Slight to 100.....	±	+	.....
Over 100.....	.....	+	+
9. Elevation of white blood cell count				
Slight to 10,000.....	±	.....	.....
Over 10,000.....	.....	.....	+
10. Elevation of temperature				
Slight to 100 F.....	±	+	+	
Over 100 F. and rising.....	.....	+	+
11. Characteristic odor.....	.....	.....	+
12. Dyspnea.....	.....	.....	+
13. Prostration.....	.....	.....	+
14. Coma or delirium.....	.....	.....	+
15. Gangrenous tissue.....	.....	.....	+

* Every condition mentioned should receive either prophylactic or therapeutic irradiation.
 †±: The symptom or finding may not be present in this stage.

transition from one stage of the infection to the other only a matter of two or three hours.

Criteria Relative to Various Stages.—It is apparent from the foregoing discussion that many details which in the past were a matter of bitter controversy concerning the exact diagnosis of gas gangrene are not now so important. At present *they are less important because if there is any doubt the patient should receive x-ray treatment without delay.* If the patient does not have gas bacillus infection, the x-rays will do no harm; if he does have gas bacillus infection, they will prevent serious toxin damage to the viscera while he recovers from the infection. To temporize may result in disaster; to give a dose of x-rays for

dangerous if properly given. Why one can make a diagnosis in the fully advanced stage, but it may have passed beyond any kind of treatment. Prevention for the suspected case or treatment for the early stage is preferable to any high-powered, time-consuming consultation or discussion concerning hair-splitting diagnostic methods.

In our early collection of data from various sources, a few cases in which gas and organisms were present in the tissues were omitted because the patients had, as far as could be judged from the data submitted, no clinical evidences of toxemia. Our only experience up to that time had been with more advanced cases with toxic manifestations. We did not know just where to place a case showing no evidences of toxemia but having some gas in the tissues as shown on the x-ray film and some organisms in the wound as demonstrated on the smear. From our later experiences in using x-rays for prophylaxis, we know that probably all of those cases were early gas bacillus infections which responded so promptly to irradiation that the exact diagnosis remained in doubt. The clinicians who took care of them made a diagnosis of gas gangrene, but we doubted the diagnoses and rejected the data; undoubtedly this was our mistake. We would now classify those cases as gas bacillus infections in the suspected or early stages, depending on the individual findings.

Where his patients are concerned, the careful clinician is well satisfied to have these very early symptoms and findings of the disease clear up while the diagnosis is still in doubt. This short period of active infection is already too long for any such

TABLE 5
DIAGNOSTIC CRITERIA AND MORTALITY RATES OF VARIOUS GROUPS OF POST-TRAUMATIC CASES

(1) ORIGIN OF CASES	(2) TOTAL CASES		(3) CLINICAL DIAGNOSIS (NO X-RAY FILMS)		(4) CLINICAL DIAGNOSIS AND GAS ON X-RAY FILM		(5) LABORATORY DIAGNOSIS		(6) METHOD OF DIAGNOSIS NOT STATED	
	No.	Died	Cases	Died	Cases	Died	Cases	Died	Cases	Died
A. Cases reported in detail by J. F. K.	12	3 (25%)	1	1 (100%)	3	1 (33.3%)	8	1 (12.5%)		
B. Cases reported in detail from other sources.....	37	4 (10.8%)	10	2 (20%)	3	0 (0.%)	24	2 (8.3%)		
Total.....	49	7 (14.2%)	11	3 (27.2%)	6	1 (16.6%)	32	3 (9.3%)		
C. Cases reported, not in detail, from other sources*	35	2 (5.7%)					12	1 (8.3%)	23†	1 (4.3%)
Total A, B and C.....	84	9 (10.7%)	11	3 (27.2%)	6	1 (16.6%)	44	4 (9.09%)	23	1 (4.3%)
D. Other cases treated by J. F. K.†.....	9	1 (11.1%)	1	0 (0.%)	3	1 (33.3%)	5	0 (0.0%)		
E. Cases seen in consultation by J. F. K. in Omaha area	31	4 (12.9%)	11	1 (9.09%)	6	1 (16.6%)	14	2 (14.2%)		
F. Cases sent to J. F. K. from other sources but not reported in detail.....	240	28 (11.6%)	70	12 (17.1%)	26	4 (15.3%)	144	12 (8.3%)		
Total, all cases.....	364	42 (11.5%)	93	16 (17.2%)	41	7 (17.0%)	207	18 (8.6%)	23	1 (4.3%)

* Series of Williams and Hartzell; Bates; Charbonnet and Cooper.

† Series of Bates; Charbonnet and Cooper.

‡ Groups D, E and F are not reported in the literature in detail, only in statistics.

toxic and dangerous disease to exist. The changes that occur in the heart, kidneys, adrenals, liver and other important viscera when the toxin reaches them has been well shown by Pasternack and Bengtson in animals and Kettle and Williams in man. From them, one should learn to prevent these infections reaching the toxin-producing stage in any individual, if it is at all possible to do so. We are convinced that early use of irradiation can prevent the serious aspects of this disease. An analysis of cases in the post-traumatic group (Table 5) reveals the interesting fact that the mortality rates for the 21 cases we treated in our institutions, for the 31 cases seen in consultation with others

that it be used have in most instances been successful. Also those cases which have been included in our statistics on evidence warranting only a clinical diagnosis show a much higher mortality rate (twice as great) than do the cases in which *B. welchii* was demonstrated as a factor in diagnosis. In other words, it should be evident that we have not padded our statistics by including a large number of cases with doubtful diagnoses in order to lower the mortality rate; the cases with questionable diagnoses which we included raised the mortality rate. Had we been technical, we might have rejected this small group with their several deaths as unproved cases of gas gangrene since no *B. welchii* were found to confirm the diagnosis. We have never at any time included any case in our statistics in which there was no evidence of toxemia, and we have not excluded any because of death.

SUMMARY

In summarizing the diagnostic criteria of a complicating and fulminating disease like gas bacillus infection, it may be permissible to consider the symptoms and findings as *minor* when in the suspected stage, *major* when in the early stage and *cardinal* when in the late stage.

The *minor symptoms* of importance are an obviously infected wound, presence of organisms on smear and a small amount of gas near the wound demonstrable on x-ray films but not

increasing. There may or may not be slight fever and other signs caused by a mild infection.

The *major criteria* of importance are an obviously infected wound, presence of organisms on culture, evidence on x-ray films of an increasing amount of gas in the tissues, considerable pain, definite evidence of mild toxemia and rise in temperature, pulse and respiratory rates.

The *cardinal signs* include all the aforementioned major criteria, and considerable swelling and discoloration of the tissues some distance from the injury. The gas is often visible as it escapes from the wound; pain is severe; evidence of toxemia has increased considerably, and often dyspnea, prostration and coma or delirium are present. Two absolute criteria of diagnosis are an increasing amount of gas and gangrenous changes in the tissues.