

Chapter XI

MORTALITY

HISTORY

As nearly as one can judge from the literature, the mortality rate for gas bacillus infection has been high since the time of Hippocrates. From 400 B.C., when the first case was described, to 1900 A.D., the exact etiology was unknown. As a result, records of the disease cannot be followed in the literature and the mortality rate cannot be accurately determined. All gangrenous processes were mixed in the records until Welch isolated *Bacillus aerogenes capsulatus* (*Bacillus welchii*) and associated it with the disease in 1900.

Forty-five to 50 per cent was the generally accepted mortality rate when x-ray therapy was introduced in 1928. Every group of statistics of cases treated with x-rays since that time has shown a greatly lowered death rate.

From August, 1928, to November, 1931, eight patients with so-called gas gangrene infection were treated with x-rays in conjunction with the usual measures employed, excepting amputation. The mortality rate was 25 per cent. In six cases, the disease was confined to the extremity, and the patients recovered. Two patients with involvement of the trunk died. It was believed that in these two cases, owing to much greater thickness of the infected part, sufficient radiation had not been given to make a fair test of the method. More penetrating radiation was then recommended for cases of involvement of the trunk. Because of the rarity of the disease, one individual, if compelled to depend on his own experience, would be many years in accumulating enough cases from which to draw conclusions. Therefore we felt justified in reporting the small number of cases observed up to that time, especially since the outcome in the cases of involvement of the extremities so strongly suggested that x-ray therapy was distinctly beneficial.

All clinical data accumulated during the care of these patients which might have had any bearing on recovery and the x-ray technical factors used in treatment were reported in detail.

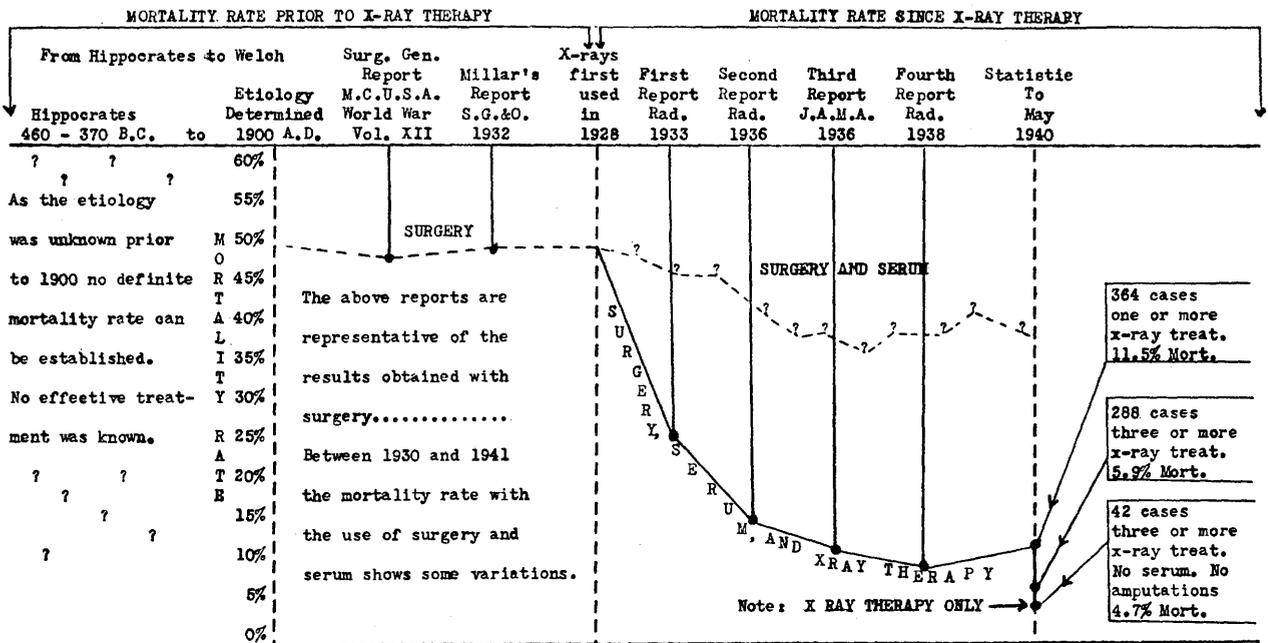


FIG. 15.—The end of gas bacillus infection as a serious infection (if x-ray therapy is used).

Some conclusions were drawn and suggestions were made. Others were urged to try the method if the opportunity should arise. This was done so that the value of x-ray therapy could be more quickly and definitely established. X-ray treatment was not offered as a specific, and no other form of indicated therapy was seriously questioned except amputation and extensive premature débridement. Some doubt was raised as to the necessity of giving large amounts of gas bacillus serum.

MORTALITY RATE IN THE LITERATURE

During the next four years, two reports (Faust and Turner) appeared in the literature, and x-ray treatment was continued as the opportunity presented itself. In November, 1935, the material on treatment of gas bacillus infection was brought up to date and reported before the Radiological Society of North America.*

After several years of experience, we are now convinced that if the x-rays are used early in the treatment of gas bacillus infection, the mortality rate will not exceed 10 per cent. Five per cent of this will be due to the direct action of the gas bacillus infection and other types of organisms and the other 5 per cent to the primary injury or disease. However, the effects of the x-rays must not be neutralized by misguided medication or the patient's strength completely overcome by unnecessary surgical procedures if this low mortality rate is to be obtained. The following discussion and its supportive data show that much of the terrorism has been taken out of gas bacillus infection by x-ray therapy.

The figures in Table 6 are readily interpreted. Each successive report includes all the cases discussed in previous reports; therefore report V shows the totals compiled up to May, 1940. The final totals up to 1940 consist of: (1) all the cases included in previous reports; (2) those reported in the literature independent of our reports, subtractions being made where duplication occurred; (3) cases from our region not previously included; (4) written case reports sent us from various sources, evidently as a result of earlier questionnaires. No attempt has been made during the last two years to collect

* Dr. Edwin C. Ernst was chairman of the Program Committee for the Radiological Society of North America and requested a report for the 1935 meeting.

new cases for inclusion with the data in this book. It had been thought that the report to the International Congress of Radiology would be accepted and would, to a great extent, prevent unnecessary amputations for this disease. Amputations, however, are still commonly resorted to, even in our immediate vicinity; and many men, even though they no longer feel able to ignore the status of x-ray therapy, choose to use sulfanilamide. Recently this practice led to increased mortality and

TABLE 6
CASES WITH GAS BACILLUS (GAS GANGRENE) INFECTION COMPLICATING

	TRAUMA			DIABETES			ARTERIOSCLEROSIS		
	Cases	Lived	Died	Cases	Lived	Died	Cases	Lived	Died
Report I*	8	6	2 (25%)	0	0	0 (0%)	0	0	0 (0%)
Report II†	39	33	6 (15.3%)	1	0	1 (100%)	0	0	0 (0%)
Report III‡	56	50	6 (10.7%)	1	0	1 (100%)	0	0	0 (0%)
Report IV§	123	113	10 (8.1%)	9	4	5 (55%)	0	0	0 (0%)
Report V	364	322	42 (11.5%)	29	14	15 (51.7%)	15	3	12 (80%)
Combined total of all types...408 cases				339 lived			69 died (16.9%)		

* Kelly, J. F.: Radiology 21:296, April, 1933.
 † Kelly, J. F.: Radiology 20:41, January, 1936.
 ‡ Kelly and Dowell, J. A. M. A. 107:1115, October, 1936.
 § Kelly, J. F., Dowell, D. A.; Russum, B. C., and Colien, F. S.: Radiology 31:608, November, 1938.
 || Kelly, J. F., and Dowell, D. A.: Radiology 37:421, October, 1941. This report include all cases which had come to our attention before May 1, 1940. For later cases see Table 8

morbidity from the disease. Now, however, the general tendency in this region is to return to the use of x-ray therapy without sulfanilamide for prevention and treatment of gas bacillus infection.

It seems that sufficient material has been collected and reported in this text to justify the use of x-ray therapy as the first means of treating a gas bacillus infection. From now on, others should report their cases, since the purpose for which case reports were sent us in the past has been accomplished, namely, the rapid evaluation of the use of x-rays in treating gas bacillus infections. We see no point in adding more cases to our totals. The statistics and other data contained in this discussion should be sufficient for any conscientious and conservative practitioner.

It is significant that the mortality rate for the usual gas

bacillus infection complicating an injury has varied between 10 and 15 per cent since we first recommended x-ray therapy in 1931. This mortality rate as represented in the early reports on our own work is not out of line with reports from elsewhere on results obtained in various parts of the country and abroad, with one exception, the Coleman-Bennett report.¹⁹ A summary of all the cases treated with x-ray and reported in the literature or by personal communication is given in Table 7.

If one were to consider only the cases treated with x-ray and reported in the literature (with the exception of the Coleman-Bennett report), the figures would be as shown in Table 7. They show a mortality of 10.6 per cent for gas bacillus infection complicating trauma; 42.8 per cent for gas bacillus infection in the diabetic group, and 62.5 per cent for gas bacillus infection in the arteriosclerotic group. The death rate (Tables 7 and 8) is lower than the mortality rate shown in Table 9, which is from our own small series. The purpose of this comparison is to show that the reports in the literature have in their combined figures the same mortality that we have been able to obtain by combining our cases with reports sent to us by others. There is nothing mysterious about these figures; others can obtain the same results. From the literature, a combined total of early (Table 7) and late (Table 8) data show 125 cases with an 11.2 per cent mortality. Again, this is evidence of consistency, when our early reports are compared with the later reports in the literature. In all instances there is only 2 or 3 per cent variation in the traumatic cases, and it is in this group in which we are most interested.

Our first two reports, the dates of which were such as to exclude danger of duplication, are included in Table 7 with other reports from the literature. Our third and fourth reports are omitted because of the danger of including in those figures some of the cases contained in other reports which are now appearing in the literature under the signature of the physicians who sent us one or more early cases.

In other instances, when reports showed an overlapping or duplication of cases in the literature, the cases considered in the previous reports are omitted from our later tabulations. The total of only 109 cases in our tabulations of the 19 reports (Table 7) is therefore smaller than the total number of cases

TABLE 7
 CASES OF GAS GANGRENE REPORTED IN THE LITERATURE*

AUTHOR	TRAUMATIC			DIABETIC			ARTERIOSCLEROTIC		
	Cases	Lived	Died	Cases	Lived	Died	Cases	Lived	Died
1. Kelly, J. F. (Radiology, April, 1933)	8	6	2						
2. Faust, J. J. (Radiology, January, 1934)	5	5	0						
3. Turner, B. W. (Urol. & Cutan. Rev., March, 1934)	1	1	0						
4. Faust, J. J. (Illinois M. J., December, 1934)	2	0	2						
5. Hanchett, M. (West. J. Surg., April, 1935)	2	2	0						
6. Kelly, J. F. (Radiology, November, 1936)	19	17	2	1	0	1			
7. Bates, M. T. (Ann. Surg., February, 1937)	5	5	0						
8. Anderson, R. (Surg., Gynec. & Obst., May, 1937)	1	1	0	1	1	0			
9. Eliason, E. L. (Surg., Gynec. & Obst., June, 1937)	1	1	0						
10. Anderson, R., and Wirth, J. E. (Staff J. Swedish Hosp., October, 1937)	1	1	0						
11. Gambill, I. M., and Cupp, H. B. (M. Bull. Vet. Admin., January, 1938)	1	1	0						
12. Faust, J. J. (Texas State M. J., October, 1938)	3	3	0						
13. Charbonnet, L. S., and Cooper, R. W. (New Orleans M. & S. J., January, 1939)	18	17	1	1	1	0	1	0	1
14. Buchanan, J. C. (Columbia M. Soc., Richland Co., S. C., March, 1939)	1	1	0						
15. Williams, A. J., and Hartzell, H. V. (West. J. Surg., Octo- ber, 1939)	12	11	1	2	1	1	4	2	2
16. Sewell, R. L. (Surgery, August, 1939)	2	2	0	2	1	1	1	0	1
17. McNamee, E. P., and Lulenski, C. R. (Ohio M. J., Octo- ber, 1939)	7	6	1				2	1	1
18. Godby, W. H. (M. J. Australia, Jan. 20, 1940)	3	2	1						
19. Bowen, A. (Mil. Surgeon, February, 1940)	2	2	0						
Total	94	84	10 (10.6%)	7	4	3 (42.8%)	8	3	5 (62.5%)

* We list here reports of others who have had success with the method; our reports, other than the first two, have been omitted.

in the reports as they appear in the literature. All cases which have been referred to us for analysis, including clinical and technical data, are included without duplications.

In Tables 9 and 10, it is possible to compare the mortality

TABLE 8

REPORTS ON GAS BACILLUS INFECTION TREATED WITH X-RAYS BETWEEN MAY, 1940, AND MAY, 1941, NOT INCLUDED ELSEWHERE

	CASES	LIVED	DIED
Kennedy, W. C. (Illinois M. J., March, 1938)	1	1	0
Newell, E. D. (Ann. Surg., July, 1939)	2	2	0
Anderson, W. D., and Olim, C. B. (Memphis M. J., November, 1939)	8	6	2
Von Briesen, D. (Southwest. M. J., May, 1940)	12	10	2
Ham, Harold (M. J. Australia, September 28, 1940)	5	5	0
Cantril, S. T. (Staff J. Swedish Hosp., Seattle, May, 1941)	3	3	0
Total	31	27	4 (12.9%)

TABLE 9

CASES OF GAS BACILLUS INFECTION IN WHICH WE HAVE BEEN IN CHARGE OR SERVED AS CONSULTANT

	CASES	LIVED	DIED
Treated by Kelly and Dowell	21	17	4 (19.0%)
Seen in consultation by Kelly and Dowell	31	27	4 (12.9%)
Total cases in Omaha Area (12 yr. plus)	52	44	8 (15.3%)

TABLE 10

CASES OF GAS BACILLUS INFECTION IN WHICH WE HAVE NOT BEEN INVOLVED EXCEPT FOR AN OCCASIONAL TELEPHONE CALL OR TELEGRAM

	CASES	LIVED	DIED
Others reported in literature	72	66	6 (8.3%)
Others reported in our files	240	212	28 (11.6%)
	312	278	34 (10.8%)

in our own cases and the cases seen in consultation and in the cases reported in the literature. Also, those reported in the literature may be further compared with those we have received from elsewhere but never reported in detail. From these figures, it is evident that the cases we have treated or the cases sent us for analysis and inclusion in our statistics have not been given any special consideration for statistical purposes. Neither the cases treated by us nor those analyzed by us have shown as low mortality or morbidity rates as those treated elsewhere and reported by others.

INFLUENCE OF TYPES OF CASES ON MORTALITY

Our first report on x-ray treatment included two fatal cases of trunk involvement and six of involvement of the extremities with recovery. Owing to the use of adequate kilovoltage in treating cases of trunk involvement since that report, it is no longer necessary to divide cases into these two groups, but the continued high mortality in the diabetic and arteriosclerotic groups as compared with the post-traumatic group necessitates a division into those three groups at this time (Fig. 16).

A separate group for cases following hypodermic injection may also be necessary as more of them are reported. Because of the increased morbidity in cases receiving combined sulfanilamide and x-ray therapy, it is also well to place those cases in a separate group.

Diabetic patients who receive serum also have so much higher mortality than diabetic patients who receive no serum that it may be advisable to group them separately until the status of the use of serum in diabetic patients is established.

In the foregoing discussion, the reduction in mortality rate for all cases of gas bacillus infection receiving x-ray therapy is quite evident. But further analysis of these cases reveals still other factors entering into the mortality rates, and these are discussed briefly.

A. *Types of Cases.*—1. Post-traumatic, Diabetic, Arteriosclerotic. When patients develop gas gangrene after trauma or as a complication of arteriosclerotic gangrene, a great difference in the mortality rate is apparent, as shown by the analysis of 408 cases up to May, 1940 (Fig. 16). The use of

cause of death and occurs in the first week. When death occurs later because of infection, it is usually due to the secondary organisms. The toxic action on the heart and other important viscera makes one especially eager to control gas gangrene at the start, before the toxic damage to these organs becomes overwhelming.

Pasternack and Bengtson have proved that vital organs, especially the heart, are severely damaged early during toxemia of *Vibrio septique* infection. Others, among them Williams, have shown that the toxin of *B. welchii* also affects the major viscera. Since it is obvious that the patient does not die of local necrosis or dies before any amount of necrosis occurs at any place, some other reason besides the local action of the organisms must be the cause of death. Toxemia is generally agreed to be that cause, and therefore the toxemia should be the center of therapeutic attack in the early stages of the disease.

E. *X-ray Technic*.—1. Inadequate Kilovoltage. In our first series we learned that kilovoltage adequate to penetrate all the diseased tissues was necessary for recovery.

2. Wrong Space Factor. Treatments given too far apart, i. e., every second day or so, are ineffective. At least one and preferably two treatments daily are necessary if the best results are to be obtained.

3. Failure to Include All Diseased Tissue. Since it is the toxin which kills the patient, neglect of an area of infected tissue means that toxin continues to be formed in that area, and failure will quite likely be the result.

4. Delay in Starting Treatment. Many patients die a few hours after receiving their only x-ray treatment. In view of what is known, it seems that any patient with gas bacillus infection is entitled to x-ray therapy as soon as the diagnosis is reasonably certain. If the patients who received only one x-ray treatment, which we consider inadequate, were excluded from our mortality statistics, the mortality rate would be extremely low. The value of early and repeated treatments is emphasized by the data contained in Table 11.

All of the foregoing experimental data and clinical observations emphasize the importance of early treatment. Patients treated so late in the disease that they only lived long enough to receive one treatment increased the mortality in that group

to 50 per cent. Those who were treated early and received three or more treatments at 12 hour intervals had a mortality of about 5 per cent. In other words, early treatment increases the patient's chance of recovery 10 times. With this difference in results, it is poor practice to withhold x-ray therapy while waiting for a positive diagnosis or to see what some unproved procedure may accomplish. This point is discussed under mortality to discourage physicians from including in their therapeutic procedures any eleventh-hour use of the x-ray and then asserting that x-ray therapy failed. The figures show that it is only one-tenth as efficient under those circumstances. If x-ray therapy is to be used, it should be given a chance in the early stages of the disease.

The help given the patient in the early stages of the infection by neutralizing the toxemia is an essential feature of the treatment. If the action of the toxin follows the "all or none law," it seems only reasonable to use any measure which tends to minimize the effect of the toxin, and clinical experience justifies one in believing that x-rays are definitely antitoxic. X-ray therapy is therefore indicated during the immediate post-traumatic period. Three days seems, from experience, to be the correct length of time to use the procedure (see incubation period, p. 199-201).

TABLE 11
RESULTS OF X-RAY THERAPY IN POST-TRAUMATIC CASES

	1 TREATMENT	2 TREATMENTS	3 OR MORE TREATMENTS	NO. OF TREATMENTS UNKNOWN
Cases.....	29	38	288	9
Died.....	14	11	17	0
Mortality.....	48.27%	28.94%	5.90%	

From Pasternack and Bengtson's work, one may also conclude that antitoxic measures used early are most effective. They stated:

It appears that if the animal can withstand the first shock of the toxin, it may live for a considerable length of time. The distinction between a dose which is fatal and one which is not, is very clear cut, i. e., all animals which show symptoms succumb sooner or later while those which survive, never show symptoms or any late effects.

Lautenschläger and Straub made the following observation:

If the toxin were injected over a much more extended period of time, the results were quite different. A quick injection of 0.03 cubic centimeters of toxin was fatal to a rabbit in 30 seconds, while six times that amount given slowly in the course of 100 minutes were borne without any reaction, according to blood pressure tracings, and was not fatal to the animal.

F. *Use of Serum.*—When x-rays are used properly, no type of cases seems to do any better with serum than without it, and in some types the mortality is increased when serum is used.

The few cases available for statistical analysis (Fig. 25) show that when x-rays are used, serum may well be omitted in the diabetic group. Because of the small number of cases, final conclusions cannot be drawn.

One might also be justified in eliminating serum from the treatment of arteriosclerotic patients. Practically all die when serum is used; therefore it would be difficult to increase the mortality. It seems that something new and different is indicated in their management, and the mortality might be lowered by withholding this source of added toxemia.

It is our impression that children also have a more difficult time with serum therapy particularly if a large amount is given. In other words, the use of serum is contraindicated in both the young and the old, and we have no evidence that it has been necessary in any case if x-rays were used.

Many patients who have failed to respond to serum have responded promptly to the x-rays, but in no case has any patient who has failed to respond to x-rays responded later to serum.

G. *Use of Sulfanilamide.*—From our own experience and from a review of the literature, we feel that the action of x-rays is inhibited by the simultaneous use of sulfanilamide. Although the mortality was not increased in the gas bacillus infection group, the intensity of the gangrenous features of the disease appeared to be increased, or at least a higher number of amputations was necessary than was the case otherwise.

Multiple amputations were necessary in at least three cases treated early with the combination in our own immediate vicinity. This is not the usual result if x-rays are used at a time when it seems that no amputation whatever will be required (see sulfanilamide, Chapter XXII).

H. *Secondary Infections*.—1. Tetanus. The almost certain means of prevention of tetanus is the administration of an adequate dose of potent tetanus antitoxin. X-rays as used to prevent the development of a gas bacillus infection will not prevent the development of tetanus. In all cases, give tetanus antitoxin; and in all cases in which one ordinarily gives tetanus antitoxin, give a prophylactic dose of x-rays to prevent gas gangrene once a day for three days. It is considered poor practice to permit tetanus to develop; through the use of x-rays we hope soon to eliminate gas gangrene entirely. It is too early to say at this time what the use of toxoid will do in the prevention of tetanus. It may do as well as tetanus antitoxin, but until it is proved, *tetanus antitoxin should be used*.

2. Hemolytic Streptococcus. This has been the cause of death in at least 1 per cent of the cases we have analyzed. The organism persists after the gas bacillus infection has cleared and involves major viscera to cause death.

3. Other Organisms. It is probable that many other organisms remain as secondary invaders to give rise to increased morbidity—osteomyelitis, for instance—if not increased mortality.

SUMMARY

As stated in the opening comment on mortality, there is little evidence of any consistent reduction in mortality figures for this disease from the time of Hippocrates until x-rays were used in its treatment. With the aid of x-rays, however, many physicians have been able to improve their results (Tables 7 and 8). This improvement has been consistent, with one exception (Coleman-Bennett¹⁹). Therefore it seems that the mortality from gas bacillus infection complicating trauma should be in the immediate neighborhood of 10 per cent and not 40 to 50 per cent, as has been the recognized level of mortality through the past centuries.

A mortality rate of 10 per cent is low, but this rate is no longer the only criterion of successful treatment. The limbs lost by unnecessary amputations must be considered in any report on the therapeutic management of gas bacillus infection. The stage of the disease in which x-ray treatments are started and whether or not the chemotherapeutic group of drugs are used are also

important items in any report. X-ray therapy adequately given has placed gas bacillus infection in the low morbidity-low mortality group of diseases. It is no longer one of the diseases in which experimental therapy on man is justifiable.

In final analysis, only the exceptional patient dies of gas bacillus infection alone if treated with x-rays according to directions. If death occurs following early and adequate treatment, there is generally sufficient evidence of death from causes other than the gas bacillus infection. When one considers the type of patient, either severely injured, senile or debilitated, who develops gas bacillus infection, one realizes that in the primary disease or injury without the complication of gas gangrene, there exists a variety of conditions which in themselves will cause death in 3 to 7 per cent of all cases.