

Chapter VI

CLINICAL FEATURES OF X-RAY THERAPY OF INFECTIONS

The facts presented in the previous discussion of experimental investigations have, in our opinion, given some basis for the roentgen treatment of infections. In addition, many reliable authorities have reported clinical observations strongly supporting the use of x-rays in infections.

As favorable clinical impressions are the result of improvement in clinical signs and symptoms as well as lowered mortality and morbidity, an analysis of cases treated with x-rays to determine if such changes actually occur seems in order. Preliminary to the analysis of cases, however, we shall tabulate and discuss the clinical signs and symptoms of the acute infections which are favorably influenced by roentgen rays. The changes are also mentioned in specific instances as they are encountered throughout the text in presentations of cases.

The favorable changes which are clinical evidence of beneficial action of the x-rays are:

1. Slowing of the pulse.
2. Lowering of the temperature.
3. Slowing of the respiratory rate.
4. Decrease of the toxemia.
5. Decrease of the pain.
6. Localization of the infection.
7. Conservation of tissue.
8. Prevention of secondary infections and minimizing of complications.
9. Shortening the course of the disease. X-rays have a favorable influence on all factors which enter into morbidity.
10. Lowering of mortality.

It should be noted that x-rays as used in infections (low dosage) give rise to no reactions which are confusing to the clinician, such as nausea, vomiting, irregular fever or disturbances in the blood picture. When used without the addition of sulfanilamide internally, they are never harmful to the patient. Before

the advent of sulfanilamide, x-rays were compatible with all other therapeutic measures.

Since x-rays aid in localizing the infection, conserve tissue, minimize the complications and shorten the course of the disease, they must in the end lessen the cost of the illness. Occurrence of only a few of the aforementioned favorable reactions would justify the use of x-rays in treating infections. Fortunately, in some conditions, practically all of these favorable reactions may be noted. This is particularly evident in the treatment of a semi-morbid patient with a gas gangrene infection who has failed to respond to all other measures up to the time x-ray therapy is given. In such a case, all of these favorable reactions often are noted, and that they are due to the administration of x-rays must be admitted since all other measures employed previously failed to produce such results.

Before entering into a discussion of the treatment of gas gangrene and the other infections, a more detailed discussion of the foregoing list of favorable reactions of radiation therapy seems indicated. A brief general discussion of the other aspects of roentgen therapy of infections will also precede the consideration of the treatment of specific infections.

1. *Pulse*.—The effect of x-ray therapy is first evident in the lowering of the pulse rate. This probably is the most reliable guide to follow in judging the condition of the patient. The drop in temperature is not as well sustained as the drop in the pulse rate; the respiratory rate is probably least affected.

If the proper kilovoltage and filter are selected, the favorable response is evident in a few hours. There is no "latent period" of several days before the action becomes evident, as is the case in treating cancer with high kilovoltage and heavy filter. If the area is overpenetrated, i. e., too much voltage and filter are used, one may not obtain the prompt response that is secured when the selection of filter and kilovoltage is more suitable to the requirements of the case. The greatest amount of good is accomplished early in the disease, i. e., during the first to fourth day of any acute infection.

That irradiation does have a beneficial effect on the pulse rate is evident from the series of cases of gas bacillus infection reported in this text. Other acute infections, when treated with x-rays, also show the same response.

2. *Temperature*.—When repeated daily temperature readings are graphically recorded during an infection, it is noted that a gradual fall in temperature usually takes place after x-ray therapy is started. This fall can be expected with greater certainty if x-ray therapy is started early in the course of the disease, at a time when resolution of the products of inflammation can be more promptly obtained. If x-ray therapy is started late and suppuration is present, the drop in temperature is less prompt or may even fail to occur until other measures are used.

3. *Respiratory Rate*.—The effect of x-ray therapy on the respiratory rate, although consistently favorable, is less striking than it is on the pulse and temperature. The graphs accompanying the discussion of cases of gas gangrene and other acute infections illustrate clearly the effect of x-rays on the pulse, temperature and respiratory rate.

4. *Toxemia*.—Probably the most striking effect of x-rays is the antitoxic action in localized infections with severe toxemia, such as gas bacillus infection, erysipelas, surgical mumps, acute spreading peritonitis and pneumonia. Anyone who has witnessed the clearing of toxic condition of a patient with an advanced gas gangrene infection following x-ray therapy and who has seen the procedure repeated in similar cases cannot help admitting the claims made for radiation therapy in this disease. If it can do as much in gas gangrene, who can deny that it has the same beneficial effect when used in similar toxic infections, such as acute spreading peritonitis and surgical mumps? This antitoxic action is most evident in gas bacillus infection, but it also occurs, as a general rule, in any localized infection which has given rise to evidence of a general toxemia as shown in the increased pulse and respiratory rates and a rise in temperature.

Two or three x-ray treatments given a few hours apart will do more to lessen the toxemia of gas gangrene than will large doses of serum. The serum, it appears, is highly effective if it is specific for the organism involved, but x-rays seem to have broad effects approaching those of a nonspecific antitoxic agent. Doub, Altemeier, Jones *et al.*, in their excellent studies on the use of x-rays in prophylaxis against pelvic peritonitis, mention that the immunity established in the pelvic structures appears to be nonspecific in that it is effective against all organisms. Thus

both nonspecific immunizing and antitoxic effects seem to result from x-ray therapy.

5. *Pain.*—One of the earliest and most consistent symptoms of gas bacillus infection is pain. This pain is promptly relieved when the patient is treated with x-rays. In the few cases of gas infection in which pain has persisted, a thrombus of a deep vessel has later been found which completely occluded an important vessel. The value of x-rays for the relief of pain is generally recognized by clinicians, and the conditions treated are not confined to the acute infections such as carbuncles but include cancer in many organs, particularly the bones, and also a variety of arthritic diseases and numberless other conditions.

The antitoxic action and the lessening of pain result in considerable subjective improvement. If the patient is comatose, he generally soon becomes rational, his appetite improves, and other clinical evidence indicating a favorable outcome appears. The decreased severity of all the symptoms naturally results in an increase in the patient's sense of well-being. This is no minor item when one is afflicted with a serious disease.

6. *Localization of the Infection.*—Early in the use of the roentgen ray in infections, many clinicians noted that most acute spreading infections lost their invasive features promptly after x-ray therapy was started. In the acute group might be mentioned erysipelas as well as the common boil and furuncle. Some of the chronic granulomatous types of infections, such as actinomycosis, if not too far advanced may also be well localized by x-ray therapy. The localization of the infectious process in boils and carbuncles in the nose and other portions of the face is a particularly well recognized achievement of radiation therapy, which has displaced early surgery completely and has been a life-saving measure in many instances. Its ability to stop the invasive tendencies of the gas-forming organisms is evident to anyone. Prior to the use of x-ray therapy, this was never accomplished in this type of infection by any other procedure except removal of the infected tissue.

7. *Conservation of Tissue.*—The ability of roentgen rays to localize an infection not only hastens recovery but also is a definite factor in conserving tissue by arresting the spread of the infection. Workers in practically all the leading medical centers of the country have seen the beneficial effects of x-rays

in localizing the infection in a carbuncle on the back of the neck. Probably the outstanding instances of their rôle in conservation of tissue is in gas gangrene where, through the use of x-ray therapy, amputation and extensive débridement as therapeutic measures have been entirely dispensed with, resulting in a saving of an entire extremity on many occasions.

8. *Prevention of Secondary Infections, Thereby Minimizing Complications.*—In gas gangrene, it is quite noticeable that the patients treated early with x-rays heal promptly and completely with little or no secondary infection by the streptococcic and staphylococcic groups. The same clinical fact is apparent in treating acute, spreading peritonitis. If x-ray treatments are started early, resolution is prompt and complete, but if the treatments are started late, during the fibropurulent stage of the disease, growth of many resistant organisms seems to be established and much less good is accomplished with radiation therapy. In the presence of a rapidly spreading, invasive type of organism, early treatment is highly beneficial to the patient, as these early invaders which are sensitive to radiation can thereby often be entirely eliminated before the more slowly growing secondary invaders which are quite radioresistant can become established. In any case in which x-ray therapy is indicated, the earlier it is given the more effective it will be.

9. *Shortening the Course of the Disease.*—By virtue of the ability of x-rays to localize the infection, lessen the toxemia, conserve the tissue and minimize the complications, it logically follows that the course of the disease is shortened. This fact is particularly evident in the treatment of such conditions as gas gangrene and acute spreading peritonitis. To have patients recover from these diseases and leave the hospital in two weeks or less is certainly an accomplishment seldom if ever witnessed unless x-ray therapy is used. In short, the use of x-rays greatly lessens the morbidity in many acute infections, but this claim can best be proved when treating gas gangrene.

10. *Lowering of Mortality.*—The mortality rate in gas gangrene has been definitely lowered as a result of x-ray therapy. So, also, has it been lowered in surgical mumps. In these two diseases, this fact is undeniable. Many clinicians now appreciate the value of x-ray therapy in other infections even though their mortality rate has not been so strikingly reduced.

The late Willis Manges, in discussing the matter with one of us, stated that, in his opinion, many other acute infections had been just as favorably influenced by radiation therapy as had gas gangrene. But in all other infections, this favorable effect could be achieved occasionally by other measures as well as by x-rays. Since these other measures were generally used simultaneously with x-rays, recovery was usually attributed to the other methods and the rôle of radiation therapy was minimized. In the treatment of gas gangrene, other measures failed to influence the disease, and therefore, x-rays, according to Manges, could no longer be denied their place in the treatment of infections.

The consistently favorable changes in the signs and symptoms in many infections following radiation therapy are mentioned throughout this text, and in gas gangrene, acute spreading peritonitis and surgical mumps the action of the x-rays is indeed impressive. Carbuncles on the back of the neck and infection around the nose and on the upper half of the face are also serious lesions which respond to radiation therapy. For these diseases and occasionally some others, radiation therapy is the treatment of necessity.

SCIENTIFIC PROOF VS. CLINICAL RESULTS

Owing to the lack of accepted scientific proof that x-rays cause the favorable clinical changes discussed, many question or even criticize such claims. But for the clinician who is interested in obtaining satisfactory results, it is recommended that he try the general plan of x-ray treatment outlined in these pages, so that he will be able to observe the changes described. With the small doses and the short space factor, no unfavorable radiation reaction, local or general, has ever occurred. In the cases in which no gain has been apparent following radiation therapy, at least, no harm has ever resulted from the technic recommended, and no confusing symptoms or signs have ever been added to the clinical picture. Clinical proof of these statements is easily obtained if it is sought.

We⁶ believe in using frequent small doses with adequate kilovoltage, now available to any sick person through a mobile x-ray therapy unit. It should also be stated that not just any x-ray technic will do; but there is nothing difficult about the applica-

tion of the correct technic. If the proper technic is not used the results, though favorable, may not be so prompt. Hudson says:

It is known that the biologic reaction is not always proportional to the product of intensity and time, for the intensity may be so small that no biologic reaction at all is produced, and also, it is not certain that a large intensity for a short time produces the same biologic effect as a small intensity for a long time though the purely physical measurements would indicate the product of intensity and time as being the same in the two cases. Consequently, it is well to specify at least two of the three factors entering the equation which defines the dose. These would be, for instance, the dose and the time for its administration or the intensity and the time of radiation.

It may be well to emphasize the fact that the physicist determines a dose based on physical measurement only. However, in roentgen ray therapy the biologic dose is the all-important quantity and at present is purely empirical. Thus, the hope of placing dosage measurements on a thoroughly scientific basis lies in the hearty cooperation of the physician, the biologist, and the physicist.⁷

By "hearty cooperation of the physician," one necessarily interprets Hudson to mean a fair knowledge of the dosage factors plus some knowledge of the clinical problem at hand and some clinical judgment. The physician has nothing he can add to the procedure except his clinical judgment after he receives from the biologist the data constituting the biologic dose and from the physicist the data constituting the physical dose.

EFFICIENCY OF X-RAYS IN THERAPY

In the treatment of certain acute infections, no other therapeutic agent can be depended on to cause a favorable reaction without untoward effects as consistently as the x-rays. There may be people who are unusually sensitive to x-rays, but we have never met one and therefore believe they are rare. At any rate, one may give the small doses of x-ray suggested in these pages without fear of any dangerous reaction even in a most sensitive person.

In a given condition, the dose of x-rays and its effect will be found to be remarkably consistent day after day in patient after patient. The same cannot be said for many other therapeutic agents now in use: the dose of and the reaction to some of the newer chemotherapeutic measures are often matters of

conjecture as well as a source of considerable anxiety to the physician if not of actual harm to the patient.

Experience has proved that one may use x-rays to treat some serious infections over a period of several days and, except for the improvement which is usually noticeable, no other sign of its action can be ascertained. A consistently favorable response is usually the only evidence one has that x-rays have been used. In experienced hands they are the simplest, safest and most effective remedy available today in the modern hospital for the treatment of many serious infections.

INDICATIONS FOR X-RAY THERAPY

1. *In local infections*, x-ray therapy is indicated for conditions (a) which are likely to spread to adjacent tissues (e. g., Ludwig's angina); (b) in which complications may develop in distant organs (e. g., erysipelas); (c) which are likely to destroy large areas of tissue (e. g., gas gangrene); (d) which are associated with severe toxemia (e. g., surgical mumps, peritonitis, pneumonia); (e) which have apparently become stationary with no evidence of repair (e. g., unresolved pneumonia).

2. *As a prophylactic measure*, x-rays are used (a) in contaminated wounds to prevent establishment of infections (compound fractures); (b) following an operation in infected areas to prevent extension of the infection (postappendectomy, after extraction of teeth, etc.); (c) preoperatively to prevent the inception of infection, as demonstrated by Doub, Jones and Altemeier in preoperative irradiation of the pelvic peritoneum; (d) In any circumstance, x-rays are valuable early in the process to prevent the inception of any infection by some of the rapidly growing organisms which may be followed by some of the secondary invaders of a more resistant character. Early treatment with x-rays will aid the defense mechanism of the patient at a time when it is most needed. As a rule, any treatment is less effective after an infection is well established than if used early in the invasion period; x-ray therapy is no exception.

3. *For pain*, x-rays relieve that due to swelling and induration incident to infection and injury, such as recent extraction of teeth. Gas gangrene and surgical mumps are often accompanied by severe pain which is relieved by x-rays.

4. *In bacteremia*, there is no contraindication to treatment of a local area of infection from which the bacteremia had its beginning, but we have not been able to determine whether or not any good has been accomplished by such treatment. If the organism is one which is susceptible to the chemotherapeutic drugs, radiation should be withheld and the chemicals may be indicated.

5. *In all infections* (*a*) which produce gas in the tissues, (*b*) which cause gangrene of the tissues, (*c*) which are acutely invasive, (*d*) which produce severe toxemia, and (*e*) which are accompanied by pain, x-ray therapy is indicated.

Do not depend on x-rays to prevent tetanus; use antitoxin. Also, do not expect x-rays to reduce a strangulated hernia or drain pus from a walled-off cavity.

CONTRAINDICATIONS

If the treatments are given under the direction of an experienced radiologist, there are no absolute contraindications as far as any pathologic process is concerned.

Before considering contraindications, the following warnings must be observed. (1) Apparatus should not be used which has not been properly calibrated in r unit output for the factors to be employed. (2) Some filter must always be used. (3) One must have knowledge of the essential dosage factor before administering any type of x-ray therapy.

Contraindications, like many other features of clinical medicine, are variable; that is, circumstances may alter their status. By this statement is meant that contraindications are conditional, often depending entirely on the clinical aspects of the case.

1. *During pregnancy*, large doses which affect the fetus should not be given over the abdomen or pelvis.

2. *The ovarian region* of a young girl should not be subjected to large doses of x-rays.

3. *Skin irritation* from chemical or other external irritants such as iodine is a contraindication.

4. *Recent x-ray treatments of unknown dosage or other forms of x-ray exposure*, such as prolonged fluoroscopic examination or the taking of numerous films, may contraindicate the use of x-ray therapy.

5. *Suppuration.*—Some workers object to the use of x-rays in the presence of acute infection, claiming that they cause suppuration; but there is no clinical evidence that they have this effect if properly applied. In our opinion, if x-rays are used early, suppuration may be avoided. This is evident in many superficial lesions; the simple furuncle, for instance, if treated early and properly, is aborted with prompt and complete resolution and without suppuration. When treatment is started later and suppuration occurs despite x-ray treatment, the course is not different from the usual course of such processes when no x-ray treatments are given.

If x-rays are not used until the lesion is so far advanced that suppuration is almost certain, suppuration may not be avoided by use of x-rays. Too much emphasis cannot be placed on the value of x-rays in the early stages of an infection in which x-ray therapy is indicated.

In the past, we occasionally saw glands in the neck which suppurated when we gave rather large initial doses (200 r or more),* but suppuration has not occurred during the past few years with smaller doses or with complete cessation of treatment if too much reaction appeared.

We are not certain about this matter of suppuration and its prevention with smaller doses, but the initial reaction which follows the first few doses serves as a guide as to how high we can carry the maximum intensity. Since we have had little inconvenience from suppurating subacute glands in recent years, we are inclined to believe that the larger doses, given too close together, should be avoided.

A maximum intensity factor of not over 40 to 50 per cent seems adequate, and by clinical observation of swelling, tenderness and other evidences of reaction in the glands one can usually judge how much radiation the particular patient will tolerate. Only a slight early increase in tenderness should be allowed. If tenderness is acute or increasing, the dose should be lowered or treatment temporarily discontinued.

Long before x-rays were ever used in the treatment of infections, suppuration was a clinical problem. Therefore all cases of suppuration are not now due to the use of x-rays. Since we feel, however, that giving too much radiation in an infected

* It is not definitely proved that the large doses of x-rays cause suppuration in the presence of acute infections; the possibility of such an effect is merely suggested.

area too rapidly may hasten suppuration, the necessity for lowering the intensity factor of the x-ray dosage should be kept in mind if suppuration is feared. Many more data, clinical and experimental, must be made available before this problem can be settled. Accurate case reports in the literature, with attention to the inclusion of all clinical and technical details, are the best sources of the required information.

An enclosed cavity containing pus should be opened and drainage established before many doses of x-ray are delivered. A treatment or two given before drainage should do some good, and some treatments after drainage is established should be the rule. The number of treatments given before and after drainage should depend on the toxemia and local evidence of the severity of the infection.