Chapter V

PRESENT USE OF ROENTGEN RAYS IN MEDICINE

Before considering the x-ray treatment of infections, it may be well to consider some features of fundamental importance in the study of the roentgen rays. Roentgen rays are used in medicine (1) as an aid in diagnosis; (2) as an aid in teaching; (3) as an aid in research; (4) as an aid in treatment of disease; (5) as an aid in prevention of disease.

Their value in the first three instances is not disputed by anyone, but many practitioners go through the entire year without once seeking the aid of x-rays in therapy. This should not be the case. Anyone with a practice of any consequence occasionally needs x-rays for the treatment of certain conditions.

Six Major Pathologic Groups

The widespread application of x-ray therapy can be easily appreciated after reviewing the six major divisions of diseases listed below. In five divisions will be found certain diseases which are definitely benefited by x-ray treatment. In the other division, the first, x-rays play a prophylactic rôle against wound infection. The place of x-rays in the prevention of the development of an infection or the extension of an infection already present is firmly established. The work of Bowen, Hunt,* Anderson, Cantril, Charbonnet and Cooper, Hartzell and Williams in the prevention of gas gangrene and of McClure, Altemeier, Doub, Jones *et al.* in the prevention of postoperative peritonitis should be consulted. The six major groups are:

1. Mechanical or traumatic—fractures, dislocations, etc.
2. Chemical or metabolic—toxic goiter, enlarged thymus, etc.
3. Infections and inflammatory—gas bacillus infection, acute spreading peritonitis, pneumonia, erysipelas, tuberculous adenitis, etc.
4. Neoplastic, both benign and malignant—fibroids, skin cancer, etc.

* Personal communication.

5. Unclassified—Hodgkin's disease, myelogenous leukemia, etc.

6. Mixed lesions—any two or more of the foregoing, such as new growths with infections.

These basic groups of diseases encountered in every-day practice are fairly comprehensive. The fact that x-rays are used successfully in the prevention or treatment of various conditions in all six of these groups indicates the present status of x-rays in both prophylaxis and therapy. In this text, discussion is confined to the use of x-rays in the prevention and treatment of a few infections.

When it is stated that a few infections will be considered, the fact is emphasized that there are a few infections for which x-ray therapy is the essential method of treatment or the treatment of necessity. There are a few infections and a few areas of the body which, if infected, should be treated with x-rays. Other measures which make the x-rays more effective should also be used. Anything should be omitted which minimizes or inhibits the action of the x-rays or necessitates reduction of radiation below an effective dose.

Regardless of the fact that not all infections are included in this discussion, the principles of radiation therapy as applied to infections are so covered that the use of x-rays in the treatment of other infections may be attempted with safety.

A glance at the variety of organisms and the diseases which they cause makes it obvious that no fixed technical routine of radiation therapy is effective in all varieties of infections. Nevertheless honest reports of worth while observations will lead to an accumulation of information which will permit adding other diseases to the group now treated successfully. Such reports also will improve the technics now used.

Varieties of Infections

No one should presume to describe the treatment of any condition without stating the exact technic used, including reasons for using it. If he gives as a reason that others have used the same technic and have been successful, that is sufficient, provided he is reasonably successful. But if he uses a technic others have used unsuccessfully and he too fails, he shows a

lack of initiative; or, if he changes from a technic which has been proved to be good and his modified technic is a failure, he shows a lack of judgment.

There are many diseases which have not been responsive to any known therapy and in which past attempts at radiation therapy have resulted either in failure or in limited success. An intensive study of the pathogenesis of these conditions and of the variations of x-ray technic which are available often justifies a reasonable form of experimentation. The choice of technic may then be regarded as a modification of some former technic and not entirely experimental.

The attempt to explain the variable technics used in the treatment of infections necessitates breaking down the broad term "infections" into specific types or clinical groups and analyzing the dosage of x-ray used in each group or type, together with the reasons for its use. The point to remember is that there are variations in x-ray technics available to meet variations in types of infections and stages of disease.

Some infections develop slowly, others rapidly; some produce toxins which damage distant organs; some confine their activity to local destruction. Some become generalized and involve other organs and tissues. Some may be termed the invaders, in that they are the early cause of the inflammation, but these organisms may later be overgrown by secondary organisms, or the original invaders may be joined in the process of destruction by secondary organisms. Some grow and invade in pure strains, as tuberculosis, whereas others seem to require the presence of one or more associated organisms in their invasion, so-called symbiosis. Also bacterial morphology and physiology may change during the various phases of bacterial growth. Such change is probably associated with changes in virulence. In addition to changes in virulence of organisms, one must keep in mind the variations in immunity or resistance of the patient. In other words, there are many factors in the problem, and one cannot be too well informed on the pathogenesis and symptomatology of the infectious diseases under varying conditions if one is to use to greatest advantage the various essential dosage factors.

Table 3 shows in a fragmentary manner the variations in pathologic effects resulting from the activity of the various types of organisms and the various x-ray dosage factors used

to combat these effects. The dosage factors must be changed to meet effectively the many variations in attack of the numerous organisms in acute infections. Finally, the stage of the disease when the radiologist first treats the patient may also call for a radical departure from the usual technic.

TABLE 3

ORGANISMS AND DOSAGE FACTORS

TYPES OF ORGANISMS* (Some Variations)	X-RAY DOSAGE FACTORS† (Subject to Variation)
Some grow rapidly, e.g., gas bacillus Some grow slowly, e.g., fungi Some grow in pure culture, e.g., tuberculosis	Kilovoltage
Some grow in mixed culture (symbiosis), e.g., streptococci and gas-formers	Milliamperage and time r units per dose
Some infections are localized but produce toxins which act on distant organs, e.g., tetanus	Distance
Some infections are localized, and cause only local destruction, often with but little general effect, e.g., staphylococci	Size of port Space factor
Some infections are rapidly disseminated through the body, e.g., a bacteremia; any organism may be present, but some are more common than others	Loss factor Total r units
Some infections are deep, involving internal organs, e.g., tuberculosis; others are superficial, involving skin and glands, e.g., staphylococcic	Maximum and minimum intensity factor
Often only soft tissues are involved but occasionally bone is also infected; type of tissue and location of involvement must necessarily influence selection of dosage factors	
Some infections are distant from a vital structure, others are in or near such vital structures, so any error in early management may prove fatal; e.g., furuncle in the nose is more serious than one on the back of the neck.	

* Partial list, an incomplete outline, but sufficient to indicate that the various types of organisms or specific diseases should have some special consideration so that the x-ray effect may be more closely observed and in the end more effectively applied.

† Fairly complete list as far as application of x-ray therapy to infections is concerned.

Table 3 shows that many pathogenic variants exist on one hand, and, on the other, that the set of dosage factors can be varied in many ways in treating the disease condition. In other words, a variable clinical problem confronts the physician, who must use his judgment in selecting the most suitable and effective combination of factors to obtain the best possible result.

Since an acute infection may change its course suddenly, one must be ready to alter technical factors, if necessary, to meet the new demand or to cease treatment if danger is past. The physician has little control over the pathogenic variants, but he has absolute control over the various dosage factors. In this control lies his greatest strength. His selection of factors and, if necessary, their variation during the course of the disease often determines the final outcome.

Therefore, no text on radiation therapy can do any more than indicate in a general way the procedure to follow. One must keep in mind that success often depends on a variation from the usual routine to obtain the desired result in a certain case. Although generalities are easily discussed, application is always an individual clinical problem. The same organism in two individuals may cause two different clinical pictures; the same organism in two different areas of the same patient may also present two different clinical problems. Extension of the original infection and numerous other developments often require a change in the method of treatment as the disease progresses. X-ray therapy calls for constant observation of the patient by a clinician who is ready to change his therapeutic procedure at any time it is indicated. Undoubtedly, x-ray therapy is given on an empiric basis. That is, the *action* of x-rays in the tissues is not understood. But one thing in x-ray therapy as applied today is understood, and that is *dosage determination.* One may not be able to foretell definitely what the reactions in the tissues will be from a given dosage, but one should be able to determine almost exactly how much dosage one has used.

Thus no one who is not familiar with all the factors entering into the administration of a given number of r units should attempt to treat with x-rays. So, although the use of x-rays may be empiric, the dosage is absolutely nonempiric. Their action in the tissues is often measurable in a few hours in clinical terms; their dosage may be stated at all times in scientific terms. Certainly *all* is not empiric in radiation therapy.

Status of X-rays in Treatment of Infections

General Considerations.—No explanation has been universally accepted regarding the exact manner in which radiation, when

used in the treatment of infections, affects either the tissues or the invading organism. Despite the lack of precise scientific knowledge concerning such action of the rays, from the time of their discovery by Roentgen in 1895 to the present day they have been used in the treatment of inflammatory lesions with more or less success.

Like many other therapeutic procedures, when first put into clinical use beneficial results occurred so infrequently that much discredit was cast on x-ray therapy. In these early attempts to cure various conditions, the underlying technical factors, biologic principles and clinical indications were so poorly understood that a successful outcome was the exception rather than the rule. This was due to lack of experience with the procedure and is no reflection on the ability or sincerity of those who gave their time, energy and even their lives to work in this field in the early days of this specialty. Nor is it intended to give the idea that much is known at this time, as real progress in this work has not yet started. From the very beginning, however, a few individuals did have sufficient success to warrant continuation of their efforts, and through their persistence and efficiency, certain facts in connection with this work were established and accepted. During all this time, the usual ridicule for any advance in a medical procedure was evident.

Any therapeutic procedure is either effective or not effective, and the only method of determining its true status is to give the method a fair trial under proper conditions with unbiased judges evaluating the results. Such tests have been made regarding the use of x-rays for many infections, and it can no longer be denied that certain conditions are now successfully treated with x-rays. Among these are many serious diseases and complications which may lead to early death or at least result in a prolonged period of disability if other methods of therapy, to the exclusion of x-ray, are used.

Regardless of the mode of action of x-rays, one is soon convinced by the results obtained. When x-ray treatment is combined with other measures, the clinician is at all times the best judge as to which procedure helps the patient. The x-ray is no miracle worker, it is no cure-all; but it is a great aid in treating infections in various locations, and it is unusually compatible

(see the exception, sulfanilamide). It should be used more often than it is at the present time.

In Responsive and Nonresponsive Conditions.—The present improved status of radiation therapy is due to an accumulation of observations by many who refused to become discouraged with this type of treatment. The numerous complications, particularly severe radiation necrosis, which often resulted from technical errors, have been practically eliminated from present-day radiation therapy. A better clinical understanding of the effects of radiation, much of which we owe to Pfahler and his associates, as well as an increased knowledge of the physics involved, filtration and dosage measurements and the introduction of the r unit have tended to improve the end-results of roentgen therapy.

Some older physicians maintain a suspicious attitude because of memories of the undesirable postirradiation sequelae or radiation accidents which, in former years, were embarrassing to the radiologist and the referring physicians as well as extremely unfortunate for the patient. On the other hand, many physicians have the mistaken idea that with lower voltage no harm can be done. This is far from the truth. Regardless of what type of apparatus one operates or what type of superficial, deep, benign or malignant lesion one is treating, one must be careful at all times. A statement that x-rays are apparently harmless when used for one condition or another must always be qualified with the understanding that a given technical procedure is implied.

In speaking of superficial and deep lesions, one must guard against placing all superficial lesions in that group responsive to the lower voltages. The tendency of some superficial malignant lesions to metastasize early means that they are not truly superficial lesions; they are potentially deep lesions. On the other hand, it must be kept in mind that some of the more deeply situated infections are radiosensitive, since it is possible to screen out with the proper filter the dangerous, longer wavelengths and still deliver a sufficient number of roentgens at considerable depth to obtain an excellent result.

The terms superficial and radiosensitive or deep and radioresistant are, therefore, not synonymous. Increased knowledge and experience have shown that some diseases or complications,

regardless of their location, may be successfully treated with relatively low voltage therapy in a short time; many require high voltage therapy for a long time; still others fail to respond to any of the present-day methods of applying radiation.

The purpose of presenting this material is not to furnish sufficient data to make it possible for one totally unfamiliar with radiation therapy to treat even the radiosensitive lesions. But, many practitioners should have available some data concerning the value or even the necessity of obtaining radiation therapy for numerous serious infections which respond promptly to x-rays. For those familiar with radiation therapy, the general plan followed by the writers in treating certain acute fulminating infections with a short space factor will be outlined.

For clinical reasons, the terms "superficial" and "deep" x-ray therapy should not be used, but more accurate terms which describe the amount of radiation required to treat each group or type of disease must be employed. Many serious conditions respond to small doses of x-rays given in a few days. This type of disease can be safely and successfully treated by anyone familiar with the operation of x-ray apparatus who understands the application of the r unit in roentgen therapy.

Training Not Always Necessary for Success

All conditions which require radiation dosage approaching the danger point of tissue destruction for their effectiveness must be treated by trained and experienced radiologists. But many acute processes requiring but a small total dose of x-rays may be successfully treated by any intelligent physician. We suggest the following division of diseases according to the amount and type of radiation required to treat each group or class of disease:

1. Infections or complications which respond to a relatively small amount of x-ray, totaling less than a full skin unit and therefore not accompanied by any visible reaction: (*a*) given in a brief time, or (*b*) given in small doses at longer intervals. But at no time should there be any necessity for the administration of an amount of radiation even approaching a visible reaction.

These conditions may be treated by any physician familiar

with the operation of x-ray apparatus, the definition of an r unit and the disease he is treating. The data in this book are confined entirely to a consideration of treatment of conditions in this group.

2. Diseases which require a mild x-ray reaction which must be maintained for a short time, two to four weeks, and then allowed to disappear.

These must be treated by a radiologist. Such diseases are not considered in this text.

3. Diseases which require several erythema doses in a short space of time; that is, heavy dosage is administered before the effects of the previous erythema doses have had time to leave the tissues. The radiation is forced into the tissues in order to produce a cumulative or sustained high saturation effect and is accompanied by visible evidence of heavy dosage.

These must be treated by a radiologist. Such diseases are not considered in this text.

4. Widely scattered tumors (such as Hodgkin's) which require a prolonged course of therapy but may show no great amount of external evidence of radiation effect except bronzing, dryness of the skin, epilation, etc.

These should be treated by one trained in radiotherapy. Such diseases are not considered in this text.

Many of the lesions in the three latter groups must have radium used in conjunction with x-ray therapy; the use of these two agents simultaneously or in rapid sequence requires special training and experience. No amount of experience or success in treating the diseases in the first group gives the therapist any training whatever which can apply in treating the lesions in the latter three groups. He should not fall into the error of believing that these small doses will be effective in the more radioresistant diseases. And without special training and experience no one should attempt to treat any of the diseases in the latter three groups.

Summary

It may be stated that the fundamentals of radiation therapy as applied to the acute infections are not difficult to master. If the physician is willing to treat the responsive infections which subside after three to seven days of treatment, he should have

no trouble. He should treat no infection which is chronic or any other type of lesion which requires a number of erythema doses.

A calculation of tissue saturation is especially easy in the inflammatory lesions which do not require more than a full erythema dose before they have subsided; after developing clinical experience in treating a few patients, confidence is quickly gained.

With these general ideas in mind, it is only necessary to learn, for a given setting on one's apparatus, the amount of radiation which constitutes not quite an erythema dose, i. e., the maximum amount of radiation which may be given in a certain time without causing x-ray reaction or other undesirable changes in the normal adjacent or overlying tissues. The operator must know how to maintain this dosage without causing a visible reaction; but in many conditions he need not give this amount to obtain the desired result. What he must do is learn the r unit output for each voltage setting available on his machine, for example, one setting for each 10 kv. variation, starting with 70 kv., which is about the lowest kilovoltage of general practical value in infections, and stopping at 140, which is the highest kilovoltage necessary for infections even in the thickest portions of the body. The higher kilovoltage requires a heavier filter, varying from 1 to 5 mm. Al or its equivalent.

Before therapy is undertaken, an accurate test of the apparatus at the different settings must be made by one trained in the work. An ionizing chamber to register the r unit output per minute, with various filters, with and without back-scatter for ports of various sizes at various distances is essential for one's peace of mind as well as one's success. There is still much to be learned in radiation therapy, but much has been learned, and all of this information is easily available to those who are interested. A properly calibrated apparatus must be used by one who has a knowledge of the fundamentals of the essential dosage factors if any treatments are to be given for any type of disease.