A general consideration of radiotherapy / by George M. Mackee.

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A GENERAL CONSIDERATION OF RADIOTHERAPY.*

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IT is a great honor to be asked to prepare a paper for the purpose of restoring the loss of confidence and to stimulate the lack of interest in radiotherapy which I understand exists throughout this section of the country. Associated with this honor is a great responsibility, for a misleading, radical or careless paper might easily negative the excellent work already accomplished by your honored President. To properly point out to you the advantages and limitations associated with this field of work, I feel it necessary to cover almost the entire subject of radiotherapy. To do this satisfactorily in a reasonably short article is a matter of considerable difficulty. I will, however, endeavor to indicate to you in a conservative manner how the rays should be used and the results that you may expect to obtain by their action upon various pathological conditions. Before considering the actual application of X-rays to diseased tissues it might

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be permissible to discuss very briefly the various methods of producing the rays, the instruments of precision, methods of protecting both the operator and patient, the cause and means of restoring the loss of confidence in radiotherapy and, lastly, a consideration of the general technics of application.

PRODUCTION OF THE RAYS.

The essential parts for the production of X-rays are two in number. First, a modified Crookes tube, which we will call an X-ray tube; second, an electrical apparatus capable of supplying a current of sufficient potential to excite the tube. The instruments employed to obtain the required electromotive force are the induction coil, the static machine and the high potential transformer. The latter although possessing certain advantages over the induction coil when used with the alternating current, has not been extensively employed in this country and it will not be considered in this paper. The Tesla coil is an apparatus which furnishes a high potential current, in fact the discharges are of the high-frequency type and such currents behave in a peculiar manner inside of a vacuum tube. Although the Tesla coil may be employed to excite an X-ray tube, I understand it has not been very extensively used, and in this paper the word coil, when used, will mean the Ruhmkorff coil.

The question for present consideration resolves itself into the static machine vs. the coil. If a physician desires to do difficult and rapid radiographic work the coil becomes a necessity. Combined with high frequency attachments this type of apparatus certainly possesses a wide range of usefulness. The disadvantages of the coil, such

as the oscillatory discharge, the troublesome interrupters, etc., are rapidly being overcome by the perfection of new instruments. The static machine, in the first place, possesses the advantage of simplicity, its operation being attended with very little difficulty. It generates a unidirectional discharge. It may be used in localities where it would be impossible to employ a coil. It is not nearly so hard on the tubes and presents a wider field of general therapeutic usefulness. By far the largest part of my radiotherapeutic and radioscopic work is done with a static machine. I am thoroughly convinced that a twelve-plate machine will answer the purpose in nearly all cases where radiotherapy may be expected to be of benefit. Although the treatments will be a little longer, they are attended with far less trouble and expense than where a coil is used. Now to conclude the subject of apparatus. If the physician who desires to enter the field of radiotherapy is a general practitioner and does not desire to do the most difficult X-ray work, I consider the static machine the proper apparatus to employ. If on the other hand difficult and rapid radiographic work is to be attempted, it becomes necessary to have a coil. It seems hardly necessary to state that if the physician desires to enter the field of radiotherapy, radiography, radioscopy and electrotherapy, he should obtain both types of apparatus.

X-RAY TUBES.

A most important desideratum in radiotherapy is the maintenance of a constant vacuum in the interior of the tube. The vacuum of a tube not having a regulating device may rise several degrees during a single exposure. For obvious

reasons therefore, a tube fitted with some regulating device is essential. The question of safety to the operator and patient may also be considered in this connection. If a tube is actuated by a static machine it is only necessary, on account of the freedom from powerful indirect rays, to cover the anterior hemisphere with material which is impervious to the X-rays, but if excited by a coil it is advisable to place the tube in a box lined with lead. Dr. Henry G. Piffard has designed a safety treatment tube which has proved eminently satisfactory. The tube is made of thick lead glass which is impervious to rays of low or moderately high penetration. A soda glass window is placed in front of the anode which allows the rays to come in contact with the part to be treated. Furthermore, the tube is fitted with an adjustable automatic vacuum regulator. It has been conclusively shown by Cole that the fluorescence of a tube when in action is not due to the passage of X-rays through the glass, but to the formation of X-rays by the contact of diverted cathodal rays with the glass. These X-rays are known as parasitic rays and they shoot off from the tube in all directions. They have proven to be both a source of trouble and of danger. As a result of recent investigations tubes will undoubtedly soon be perfected where, by means of a pipe of suitable material placed within the tube, the cathode stream will be conducted directly to the target. A minute hole in this pipe, placed in front of the anode, and covered with some material like mica or aluminum, will allow of the passage of X-rays but will entirely confine the cathode stream. Such a tube will answer the requirements of radiography and will be a safety treatment tube as well.

RECENT INSTRUMENTS DESIGNED FOR THE PURPOSE OF ACCURACY AND EFFICIENCY IN RADIOTHERAPY.

Unfortunately, radiotherapy has not as yet reached the stage where it can be termed an exact science. Much work has been done in the hope of perfecting instruments whereby X-rays of a known quality might be employed in exact dosage. These endeavors have not been associated with laudable success, although some headway has been made. In the first place, we know that a given tube will, under varying degrees of vacuum and varying degrees of energization, deliver rays that vary in their ability to penetrate different thicknesses of a given impediment. This degree of penetration may be determined by the clever device of Benoist. The radiochromometer, however, only ascertains the maximum and not the average penetration of the rays which issue from the tube. In other words it simply indicates the existence of certain rays which are capable of passing through a certain thickness of aluminum. In routine clinical work, if one is well acquainted with his apparatus, practically the same information may be obtained by observing the spark gap which registers the tube resistance. Also by the color of the fluorescence, a yellow glow indicating a maximum of low rays, while a green color indicates a maximum of high penetrating rays. We still lack some device whereby we can estimate the relative proportion of soft and hard rays which together make up the mass of radiation. Personally when an inspection of the fluorescence of the tube and the spark gap leave me in doubt, the examination of a heavy bone mounted upon a shielded handle (as suggested by Piffard) will give the required information. The object of determining the quality of the

radiation is to select such radiation as will expend the greater part of its energy within the depths it is desired to effect.

Now having settled the question of quality it becomes necessary to estimate the quantity of the selected radiation to be employed to obtain a given result. It must be sufficient to accomplish the purpose for which it is to be used, and yet it must be carefully controlled as a safeguard to the patient. To accomplish this purpose there are several devices upon the market which are supposed to measure the quantity of radiation delivered in a given unit of time. The first to be considered is the Holtzknecht chromoradiometer, which method consists of exposing a certain secret chemical combination to the rays and comparing the color changes taking place with an arbitrary color scale. To the same class belong the tablets of Sabouraud and Noiré of Paris, which consist of platinocyanid of barium, and which change from yellow to brown under the influence of the rays. Although I confess to having obtained good results by the use of the pastiles of Sabouraud and Noiré, both these methods are dangerous and unreliable. A great deal depends upon personal equation, upon atmospheric conditions and also upon many other factors. These methods have been rather extensively employed throughout Europe, but they have never been in favor in this country.

In the literature one finds accounts of many instruments originated for the purpose of estimating the quantity of radiation. Time will hardly allow of a consideration of these devices. For the present purpose it will suffice to know that there has been no method devised as yet which has stood the test of time, or which has received extensive confirmation.

There is one instrument, however, which has been of considerable service. I refer to the magnetic milliampèremeter. A milliampèremeter in its proper position registers the actual amount of current passing through the tube, from which is deduced the amount of radiation given off. To obtain accurate information the milliampèremeter must be used only with a unidirectional current such, for instance, as is derived from the static machine. When used in connection with a Ruhmkorff coil where we are dealing with an oscillating current certain precautions must be taken. The direct or break current from a coil is the one we desire to utilize, while the make or inverse current is the one we try to exclude. These discharges do not bear a constant relation to one another. Usually the direct discharge will predominate, but at times the inverse discharge will equal or even become greater than the direct current. As a rule one can readily detect the inverse discharge by the appearance of the tube and also by the fact that the needle of the milliampèremeter frequently moves in the wrong direction. A much better way to detect the inverse current is to place an oscillascope in the circuit. If the inverse discharge is found to be present a Villiard valve or a modification of the same should be employed. This valve if placed in the proper position will, as a rule, completely choke off the inverse current and the milliampèremeter will read correctly.

Now to sum up the question of precision. We are able to estimate the maximum penetration of a given radiation by means of the appearance of the fluorescence, by the length of the spark gap and by the radiochromometer or modifications of the same usually designated

as penetrometers. The milliampèremeter also furnishes valuable information regarding the tube resistance, thereby giving an idea as to the character of the vacuum. We have no accurate means of estimating the quantity of radiation, but by the use of an ammeter to register the amount of current passing through the primary circuit, providing the coil is used; a milliampèremeter to register the amount of current passing through the tube, providing the above mentioned precautions are taken, and the operator is thoroughly familiar with every part of his apparatus, the quantity of radiation can be judged with a fair degree of accuracy. I cannot leave this subject without a word of caution regarding the pernicious habit of the operator using his hand to judge of the quality and quantity of the radiation. The hand should never be employed for this purpose. Furthermore the fluoroscope should be fitted with lead glass to protect the face and eyes, and mounted upon a large screen, to protect the body.

PROTECTION TO OPERATOR AND PATIENT.

The question of protection to both operator and patient is an important one. Carelessness for the patient's safety may lead to severe burns. Carelessness on the part of the operator regarding his own safety may lead to permanent sterility and possibly impotence as well. These facts are well known, but just what effect deleterious continued radiation may have upon the nervous, circulatory and lymphatic systems as well as the internal organs is not so well understood. In any event the occurrence of these accidents to the operator can be entirely avoided by proper protection. Suitable protection for the patient

will at least safeguard every part but the immediate tissue under treatment. As has already been stated, if the tube is to be actuated by a static machine it is only necessary to cover the anterior hemisphere with material impervious to the rays, providing the operator stands at some distance from the tube. The patient should be still further protected by the utilization of suitable funnel shields connected to the tube covering. When a coil is used the tube should be placed in a lead-lined box, having an opening in front fitted with funnel shields of various sizes, and a lead glass window at the top through which the operator may watch his tube. For the majority of cases to be treated the Piffard tube answers the purpose of protection admirably and saves one the trouble and expense of other methods.

THE CAUSES OF AND THE MEANS OF OVERCOMING THE LOSS OF CONFIDENCE IN RADIOTHERAPY.

In the latter part of 1895 the medical profession was made acquainted with Roentgen's astounding and important findings. Both the medical and public press soon contained greatly exaggerated accounts of the wonderful diagnostic possibility of the X-ray. Then followed glowing descriptions of the marvelous effect of the rays upon certain pathological conditions, particularly the dreaded malignant growths. It was soon discovered that most cutaneous affections would yield to the treatment, that goitre, splenic leukæmia and many other diseases would respond to X-radiation. The dangerous character of the rays was unknown, and the world was optimistic indeed. Then came the shock. It was found that many malignant tumors would not yield to the treat-

ment, and in a large percentage of the growths that did respond, the improvement was only temporary. Radiographs were so often misinterpreted that the courts refused to consider them as reliable evidence. Operators became sterile, cancers developed upon their hands, and many patients were badly burned. Physicians found they could not control the radiation; that is, they would treat one patient and obtain a most satisfactory result, while another patient treated in apparently the same manner would develop a severe radiodermatitis. These observations were not only published in the medical journals, but found their way into the lay press as well. The whole thing was mysterious; optimism rapidly gave way to pessimism. Fortunately, however, the old slang phrase and maxim, "A good thing can not be held down," remained true in the case of radiotherapy. A few conservative and scientific men retained their faith in the X-ray and instituted studies, investigations and observations, the result of which has been to lay a firm and reliable foundation upon which progress can take place. To-day, although there is much to be learned, one may say that the value of the X-ray and its proper application is well enough understood to make it of great value in the field of diagnosis and of therapy.

In radiotherapy the student of the X-ray rarely causes a burn unless such effect is desired. The experienced radiographer obtains the most difficult pictures without untoward results, and the logical interpretation of radiographs is gradually restoring their value as legal evidence Much harm is still being done, however, by unscrupulous manufacturers and by unskilled and care-

less practitioners. Enough has already been said to show that more is required in radiotherapy than to push the button and let the tube do the rest. That there are physicians who work upon this principle has been demonstrated to me time and again. There are many other abuses which have aided in producing this loss of confidence. There are, for instance, many physicians who do not believe the X-ray to be of value as a therapeutic agent. It is hardly necessary to say that such opinions are usually based upon careless study and a superficial consideration of the subject. Another factor is the treatment of disease by X-radiation when more suitable means might be employed. In this connection I would like to quote the following from Piffard's writings: "When a gentleman tells me that he uses the X-ray as his regular and routine treatment for all cases of acne and another says the same concerning eczema, the most charitable construction is to consider them radiomaniacs and to regret the poverty of their therapeutical resources. If they are dishonestly employing X-rays when other more suitable means are at command, there is but one name that can be applied to them, namely, radiografters."

Radiologic misinformation is another source of trouble. This is a term advanced by Piffard and means the incorrect and misleading statements which are to be found in certain papers, text-books and catalogues. The following incident may be mentioned as an illustration: A certain dealer in X-ray outfits advertised the Piffard safety treatment tube. It was stated that the tube was constructed of material impervious to the X-rays and that it was fitted with a lead glass window which would positively prevent the development of burns. Incorporated in the ad-

vertisement was an illustration showing the tube in direct contact with the skin. I am quite certain that Dr. Piffard would not sanction the use of his tube in this manner, nor do I think the advertiser properly interpreted the word safety.

The public press has been and always will be a serious obstacle to progress. In one paper one reads of the wonderful cures and marvellous diagnostic results of the X-ray. In another paper will appear accounts of the disastrous effects, such as sterilization, the production of cancer and even death by the use of the X-ray. In the *New York Times* of Sunday, April 14, 1907, there appeared an article upon X-radiation which undoubtedly produced a very unfavorable and entirely faulty impression in the minds of those who had the misfortune to read it, for it must be remembered that the lay mind will interpret such writings in an entirely different manner from the specially educated physician. There is no way to keep such matter out of the public press, because they can abstract from the medical journals, but many of these writings are the report of interviews and, of course, these can be refused by the physician.

To restore confidence in radiotherapy and to establish a firm foundation for one of the most valuable therapeutic remedies which science has given us requires the co-operation of every physician. The operator should possess a theoretical knowledge of the X-ray as well as a practical familiarity. He should not only be familiar with its biological effect upon human tissues, but should study its action upon the photographic plate, for experimental radiography will develop much useful knowledge. I feel confident that if every physician who is entering, or who has en-

tered this field, will employ the X-ray when indicated and only when indicated, will employ a safe technic, will instruct his patients regarding the advantages and limitations of the Roentgen ray and will make conservatism and caution his motto, radiotherapy will soon occupy the position it justly deserves.

DISEASES TO BE TREATED AND HOW TO TREAT THEM.

The class of diseases known as cutaneous affections offers the most satisfactory field for the work of the radiotherapeutist; we will therefore consider the dermatological disorders first. Among the most rebellious cutaneous affections with which the physician has to deal, the vegetable parasitic diseases of the hairy regions rank high as examples wherein the use of the X-ray has produced brilliant results. In all probability these diseases are cured by the production of complete epilation, and possibly by the bactericidal action of the rays. In tinea tonsorans and favus, on account of the rotund contour of the skull, it is necessary to treat one section at a time. These areas are carefully marked out with ink, the remaining portion of the scalp suitably protected, and the treatment to consist of five- or ten-minute applications three times weekly until epilation or a mild erythema occurs. The treatment of favus and disseminated ring-worm of the scalp by this method usually requires from three to fifteen weeks, but this is indeed a short time if one considers the number of years demanded by other methods of procedure. Rays of low penetration should be employed both as a protection to the brain and to obtain a quick epilation. Rays of medium or moderately high penetration will frequently produce epilation

without the occurrence of erythema. In most of the diseases to be treated by X-radiation it is customary to place the tube so that the target is about eight or ten inches from the skin. Again, with the technics as employed in America, unless the operator has had considerable experience and is thoroughly familiar with his apparatus, it is advisable to give two or three five-minute exposures and wait two weeks, when if erythema fails to appear, the methodical treatment may be instituted. Such procedure is thought advisable as a means of protection against the possibility of individual susceptibility. In tinea barbæ and non-parasitic sycosis the effect of X-radiation is quite the equal of the above-mentioned conditions. Remarkable results are often obtained in sycosis vulgaris. Not infrequently this disfiguring disease, after resisting ordinary treatment for ten or fifteen years, will yield to three or four applications of the X-ray without causing epilation or the production of erythema. The percentage of recurrences in this class of cases is very small, providing the treatment has been thoroughly applied. Patients treated for tinea tonsorans, favus and tinea sycosis cannot be considered cured until repeated miscroscopic examinations fail to demonstrate the spores.

In hypertrichosis, although good results may be obtained, this method of treatment is not to be commended. Epilation is only transient and must be effected several times before the hair will entirely cease to grow. This procedure invites the risk of a severe burn, and even in cases where no inflammatory reaction occurs, the oft-repeated exposures will frequently cause the skin to become wrinkled and to assume a glazed and atrophic appearance.

In lupus vulgaris the X-ray usually gives very superior results. It is frequently necessary to cause a mild radiodermatitis. The cosmetic effect is better and the percentage of recurrence is no greater than when other methods are employed. In this disease, as in most cutaneous affections, the very low penetrating rays are usually employed, but I prefer rays of medium penetration.

Erythematous lupus does not yield very well to X-radiation, in fact the condition is frequently exaggerated by this treatment. Much greater satisfaction will be obtained by the use of the actinic rays, the high-frequency spark and chemical treatment.

Although the disease known as tuberculosis verrucosa cutis is amenable to X-radiation, it is advisable to treat it surgically rather than with the time-consuming and expensive X-ray treatment. The rays may be used to prevent recurrences.

In the treatment of keloid X-radiation gives better results than any other agent heretofore employed. Especially is this true of acne keloid where it appears to possess a specific action. Occasionally it will be found necessary to push the treatment to the point of severe erythema. In this disease, as in most cutaneous affections, it is advisable not to confine the rays strictly to the affected tissue but to treat a little outside of the actual disease. Recently I had the pleasure of treating a gentleman who had developed an extensive acne keloid, or to be more exact a condition known as dermatitis papillaris capillitii, upon the back of the neck. The tumor was four and one-half inches long, three inches wide, and about two inches thick. The tumor was X-rayed irregularly for a period of four months when

it entirely disappeared. This patient was presented by Dr. J. A. Fordyce at the Sixth International Dermatological Congress. Cicatricial tissues resulting from burns and other accidents do not always respond to X-radiation. In rhinophyma the results of X-ray treatment are frequently beneficial.

In obstinate cases of karatosis palmaris and plantaris the result of this treatment is highly satisfactory and the relief afforded appears to be more permanent than when other means are employed.

There are certain forms of chronic eczema which, especially when associated with infiltration and intense pruritis, and which have failed to respond to the ordinary forms of treatment, will frequently respond to X-radiation. The same may also be said of diseases like petyriasis rubra, hypertrophic lichen planus, etc. Mycosis Fungoides may be indefinitely controlled, but not cured, by X-radiation. In any affection accompanied with considerable pruritis this treatment will invariably overcome the itching, but it is considered preferable to employ other means to accomplish the purpose.

The X-ray undoubtedly possesses a specific action in nearly all cases of acne. Especially is this true of acne indurata. Its curative action in all probability depends upon the atrophic changes produced, its power of promoting absorption, and possibly also by its bactericidal action. Recurrences are quite common, but repeated exposures will produce a complete cure. The X-rays, however, should never be used for the treatment of acne until every other resource has been exhausted. Very soft rays are usually advised, and fre-

quently it is necessary to produce a mild erythema. I have, however, obtained good results by the use of rays having a little harder quality. Rays of this character are less liable to burn the skin, and not only appear quite as efficacious, but the result seems to be more permanent. In rosacea this treatment is of little or no value.

The X-rays have been used with success in alopecia areata, psoriasis, verruca, hyperidrosis, varicose ulcers, nevus and many other cutaneous affections. As a rule these conditions can be cured by simpler means, and it is better to employ the X-rays in very rebellious cases only.

Malignant tumors. The X-ray treatment of deep-seated malignant growths has given very poor results and should only be employed in inoperative cases or as a post-operative procedure. Sarcomata appear to yield to the treatment better than carcinomata. Cancer of the superficial mucous membranes may respond to the treatment, but the results are so uncertain that such procedure should not be advised whenever a thorough operation is possible. In cancer of the breast, although the disease may be arrested, and even apparently cured, one is not justified in advising X-radiation unless the case is inoperable or the patient refuses surgical aid. In cutaneous malignant neoplasms X-radiation has given greater satisfaction, but even in these cases, if the tumor can be thoroughly removed by surgical methods, it is probably better to advise such procedure. There is one type of epithelioma which deserves special consideration. I refer to the rodent ulcer. This disease is usually situated upon the face, and frequently in such position as to be prac-

tically inaccessible to the surgeon. In such cases the cosmetic result is far superior and recurrences probably less common than where surgical methods are employed. In treating malignant tumors it is preferable not to employ rays of soft quality. With the exception of rodent ulcers a superficial burn is of no great value, and in most cases it is advisable to use medium or hard rays and plenty of them. In this connection it might be stated that post-operative X-radiation to prevent the recurrence of malignant tumors is apparently of great value.

The treatment of pulmonary tuberculosis has proved to be a failure. Although this treatment is of value in tubercular bone lesions and sinuses, preference should be given to the surgeon. Tubercular glands, especially when associated with scrofuloderma, frequently react better to X-radiation than to surgical methods.

Certain cases of rheumatism may be greatly benefited by mild application of high penetrating rays. This is especially true of chronic non-suppurative arthritis associated with considerable periarticular infiltration and more or less pseudoankylosis. This treatment should only be used as an adjunct to other methods.

The literature contains several reports of the successful treatment of goitre by X-radiation. I have treated several such cases by this method, and only received a good result in one case, which happened to be of the exopthalmic variety. To be effectual one must employ large quantities of rays possessed of hard quality, and they should pass through the tumor horizontally, so as to avoid the spinal cord.

Splendid results have been obtained in splenic leukemia by this method of treatment. When applying the rays to deep-seated tissues the quality must not only be very hard, but they should be filtered through tin-foil, aluminum or leather so as to avoid injuring the skin by soft rays, which are always associated, to a greater or less extent, with the hard rays.

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