X-RAY DOSAGE
IN TREATMENT AND RADIOGRAPHY

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IN

TREATMENT AND RADIOGRAPHY

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PREFACE

THE method of dosage described in this book is practical and has been used by the authors in the clinics and private practice for the past four years. We regard this as safe, within certain limitations, namely, between a three- and ten-inch spark gap and between six and twenty inches' distance.

The unfiltered dosage is especially indicated in the treatment of superficial skin conditions. The filtered dosage, within the above limitations, is useful in the treatment of leukemia, Hodgkin's disease, tonsils and adenoids, toxic goitre, and tubercular glands. In the recent method of treatment of cancer, using high voltages above ten inches, we have had no experience. It is also essential to bear in mind that our figures are based solely on aluminum as a filter.

This method is *especially applicable and useful to the roentgenologist* in determining the number or amount of each exposure in radiographic work. For example, it is often necessary either to repeat the exposure in sinus cases or check up another

man's findings. If the factors used on the first exposure are known, it is a comparatively easy matter to determine just how many more plates can be obtained without producing either a temporary or permanent alopecia. The above holds true also of radiographs of the kidney, pelvis, spine, gastro-intestinal tract, and in fact any condition where long exposures are required and the patient is being passed from one radiologist to another for diagnosis. These are the cases that are liable to receive an *x*-ray burn unless the amount of ray is definitely taken into consideration.

Much of the material in this book has been rewritten from articles of ours which have appeared from time to time in the following journals: American Journal of Medical Sciences, American Journal of Dermatology and Syphilis, American Journal of Roentgenology, New York Medical Journal, New York Medical Record, American Journal of Electrotherapeutics and Radiology, Journal of Experimental Medicine, Journal of the A. M. A., and The Journal of Radiology.

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X-RAY DOSAGE

CHAPTER I

UNFILTERED *X*-RAY DOSAGE

THE standard of roentgen-ray dosage is known as the erythema dose; in other words, the quantity of roentgen ray necessary to produce an erythema of the skin in from ten to fourteen days after exposure.

The amount of radiation reaching the skin of the part exposed is determined by four fundamental factors: the voltage, expressed as K V or kilovolts; the milliamperage or current, expressed as M A or milliamperes; the time, expressed as T in minutes; and the distance, expressed as D in inches from the target of the tube to the skin. Voltage, or K V, is very often expressed in the number of inches between the spark gap terminals which relatively correspond to the number of kilovolts. The actual determination of the spark gap is obviously just the amount of pressure or

voltage that gives a spark across the terminals without the tendency to arc, and which, at the same time, maintains the milliamperage desired in the tube.

The analysis of these four factors necessitated maintaining three of them constant throughout the exposure, and varying the one under investigation. Thus, maintaining 3 Sp G 3 M A for five minutes at a distance of 8 inches produced an erythema in the usual time, ten to fourteen days, over an area of the chest which happened to be covered with hair. The third week after exposure the hair came out and showed no signs of returning at the end of six months. Another area of the chest was exposed and given 3 Sp G 3 M A at a distance of 8 inches for four minutes instead of five minutes. In this area the hair fell out during the third week, and had all returned by the fourth month after exposure.

The latter formula, namely, 3 Sp G 3 M A, four minutes with 8-inch distance, we will call one skin unit. This, then, is the dose required for the treatment of ringworm of the scalp, thus insuring the return of the hair, whereas if five-minute

exposures were used the hair would not return, and a certain amount of permanent baldness would ensue.

If a pastille were placed 8 inches from the target of the tube and the factors 3 Sp G 3 M A and four minutes' time given, the color produced on the pastille would correspond to one on the scale of a Holzknecht radiometer which, expressed in Holzknecht units, would be 4 H, because Holzknecht readings were originally all made at half distance.

By using the pastilles and a Holzknecht radiometer, it has been found that if you double the time, the voltage, or milliamperage separately, maintaining the other three factors constantly, you will double the dose when the roentgen ray is used without a filter; also that by placing two pastilles, one at full distance and the other at half the distance from the target of the tube to the skin, the pastille reading at the half distance will be four times that of the one placed on the skin or full distance, therefore, it varies inversely as the square of the distance, the same as the law of light.

3 Sp G 3 M A 8 D 2 minutes = ½ skin unit
6 Sp G 3 M A 8 D 2 minutes = 1 skin unit
3 Sp G 6 M A 8 D 2 minutes = 1 skin unit
3 Sp G 3 M A 16 D 4 minutes = ¼ skin unit
3 Sp G 3 M A 8 D 4 minutes = 1 skin unit

The dose, then, of 1 skin unit, which we have adopted as our standard for unfiltered roentgen-ray therapy, would be expressed as follows:

$$\frac{3 \text{ Sp G} \times 3 \text{ M A} \times 4 \text{ minutes}}{8 \text{ inch} \times 8 \text{ inch}} \text{ or}$$

$$\frac{3 \times 3 \times 4}{8 \times 8} \text{ or } \frac{3 \times 3 \times 4}{8 \times 8} = \frac{9}{16} = \frac{36}{64}$$

The standard formula for an erythema dose would be:

$$\frac{3 \text{ Sp G} \times 3 \text{ M A} \times 5 \text{ minutes}}{8 \text{ inch} \times 8 \text{ inch}} \text{ or}$$

$$\frac{3 \times 3 \times 5}{8 \times 8} \text{ or } \frac{45}{64}$$

In order to prove the actual working of the above formulas, let us take the factor as expressed in the above list.

1. If $\frac{\text{3 Sp G 3 M A 2 minutes}}{\text{8 inch D} \times \text{8 inch D}}$ is used, what is the dose?

$$\frac{3 \times 3 \times \cancel{2}}{8 \times \frac{\cancel{8}}{4}} = \frac{9}{32}$$

$$\frac{3 \times 3 \times 4}{8 \times 8} = \frac{36/4}{64/4} = \frac{9}{16}$$ the standard or one skin unit

$$\frac{9}{32} \div \frac{9}{16} \text{ or } \frac{\cancel{9}}{\frac{\cancel{32}}{2}} \times \frac{\cancel{16}}{\cancel{9}} = \tfrac{1}{2} \text{ skin unit}$$

2. With 6 Sp G instead of 3 Sp G, other factors remaining constant, the process would be:

$$\frac{\cancel{6}^{3} \times 3 \times \cancel{2}}{8 \times \frac{\cancel{8}^{\cancel{4}}}{\cancel{2}}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{\cancel{9}} = 1 \text{ skin unit}$$

3. With 6 M A instead of 3 M A, other factors remaining constant, thus:

$$\frac{3 \times \overset{3}{\cancel{6}} \times \cancel{2}}{8 \times \underset{2}{\cancel{8}}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{9} = 1 \text{ skin unit}$$

4. With 4 minutes' time instead of 2 minutes' time, the result would be:

$$\frac{3 \times 3 \times \cancel{4}}{8 \times \underset{2}{\cancel{8}}} = \frac{9}{16}$$

$$\frac{9}{16} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{16}} \times \frac{\cancel{16}}{\cancel{9}} = 1 \text{ skin unit}$$

5. With 16 inches distance instead of 8 inches and 4 minutes time with 3 M A and 3 Sp G, the result is:

$$\frac{3 \times 3 \times \cancel{4}}{16 \times \underset{4}{\cancel{16}}} = \frac{9}{64}$$

$$\frac{9}{64} \div \frac{9}{16} = \frac{\cancel{9}}{\cancel{64}_{4}} \times \frac{\cancel{16}}{\cancel{9}} = \tfrac{1}{4} \text{ skin unit}$$

Now let us take the factors as given under 1, but assume that you want to use 3 Sp G 3 M A and 8 inches distance, and desire to give one half of a skin unit and do not know how much time to use.

$$\frac{3 \times 3 \times T}{8 \times 8} = \frac{9}{64}$$

The standard for one skin unit is $\frac{9}{16}$; for ½ of a skin unit it would be $\frac{9}{32}$. If, then, $\frac{9}{64}$ represents all of the factors except time, and $\frac{9}{32}$ equals ½ skin unit,

$$\frac{9}{32} \div \frac{9}{64} = \frac{\cancel{9}}{\cancel{32}} \times \frac{\cancel{64}^{2}}{\cancel{9}} = 2 \text{ minutes' time.}$$

With the factors expressed in 2, what would the Sp G be using 3 M A 2 minutes' time at 8 inches' distance to produce 1 skin unit?

$$\frac{\text{Sp G} \times 3 \times 2}{8 \times \frac{9}{4}} = \frac{3}{32}$$

$\frac{9}{16} = 1$ skin unit, therefore,

$$\frac{9}{16} \div \frac{3}{32} = \frac{\overset{3}{\cancel{9}}}{\underset{16}{\cancel{16}}} \times \frac{\overset{2}{\cancel{32}}}{\underset{3}{\cancel{3}}} = 6 \text{ Sp G}$$

With the factors expressed in 3, what would the M A be, using 3 Sp G for 2 minutes' time and 8 inches' distance to produce 1 skin unit?

$$\frac{3 \times \text{MA} \times 2}{8 \times \frac{9}{4}} = \frac{3}{32}$$

$\frac{9}{16} = 1$ skin unit, therefore,

$$\frac{9}{16} \div \frac{3}{32} = \frac{\overset{3}{\cancel{9}}}{\underset{16}{\cancel{16}}} \times \frac{\overset{2}{\cancel{32}}}{\underset{3}{\cancel{3}}} = 6 \text{ M A}$$

With the factors expressed in 4, at what distance would it be necessary to place the patient

from the target of the tube to produce 1 skin unit, using 3 Sp G 3 M A 4 minutes' time?

$$\frac{3 \times 3 \times 4}{D \times D} = \frac{36}{D \times D}$$

$\frac{9}{16}$ = 1 skin unit, therefore,

$$\frac{36}{D^2} \div \frac{9}{16} = \frac{\overset{4}{\cancel{36}}}{D^2} \times \frac{16}{\cancel{9}} = \sqrt{\frac{64}{D^2}} = \frac{8}{D}$$

D = 8 inches' distance.

The distance required to produce one skin unit is found by dividing the product of the three known factors by the standard formula for one skin unit $\frac{9}{16}$ instead of dividing the standard formula $\frac{9}{16}$ by the fraction with unknown distance as exemplified in obtaining the other factors.

The determination of distance and the number of skin units are both obtained by the same method.

From the foregoing calculations it is evident that the dose of unfiltered roentgen ray can be accurately and easily determined for both fractional and massive dosage. When all four factors are known, the product of their formula divided by the product of the standard formula for one skin unit, namely, $\frac{9}{16}$, will indicate the dosage in skin units. When, however, any one of the four factors is unknown and the other three decided on, the product of the standard formula for one skin unit, namely, $\frac{9}{16}$, divided by the product of the three known factors, indicates the unknown factor for one skin unit. When distance is the unknown factor, note the exception to this rule.

Owing to a proportionately large filtration of the ray generated below a 3-inch gap by the glass in the Coolidge tube, the above rule of unfiltered dosage does not apply.

CHAPTER II

X-RAY BURNS IN RADIOGRAPHY

THIS method of estimating roentgen-ray dosage is also applicable in determining the number of plates that can be taken of a given case without the production of a permanent alopecia or roentgen-ray burn.

For instance, how many plates or exposures can be made of a frontal sinus or anteroposterior diameter of the head without producing an epilation or erythema of the scalp? The formula or factors for such an exposure might be as follows:

Sp G	M A	D	T
5½	25	18 in.	10 sec.

This means that the plate is 18 inches from the target of the tube, and in this instance the scalp is 10 inches from the anode. In order to find the dosage which the scalp will receive, the formula must be changed from 18 inches to 10 inches.

Sp G	M A	D	T
5½	25	10 in.	10 sec. = ⅙ of a minute

$$\frac{5\frac{1}{2} \times 25 \times \frac{1}{6}}{10 \times 10} = \frac{275/12}{100} = \frac{11}{48}$$

Take the standard formula for an erythema dose:

$$\frac{3 \times 3 \times 5}{8 \times 8} = \frac{45}{64}$$

Divide the erythema dose by the dose for each exposure:

$$\frac{45}{64} \div \frac{11}{48} = \frac{45}{\cancel{64}\,4} \times \frac{\overset{3}{\cancel{48}}}{11} = \frac{135}{44} = 3\tfrac{3}{44} \text{ plates}$$

Thus three plates with these factors would not cause an erythema, but may produce a temporary alopecia.

By dividing the product of the factors of the standard formula for an erythema dose, namely, $\frac{45}{64}$, or one skin unit $\frac{9}{16}$, by an exposure formula, provided the skin distance is taken instead of plate distance, the roentgenologist can determine the number of plates he can make without producing an erythema or temporary epilation.

To illustrate the practical application of the above fraction $\frac{9}{16}$, let us take the factors given in the "U. S. Army *X*-Ray Manual" for the various exposures, then estimate the skin difference from the target of the tube in each position of a patient whose measurements are a little above the average, substituting the skin distance in each case for the plate distance.

	Sp. gr.	Ma.	Time minutes.	Plate distance, inches.	Skin distance, inches.	Number of plates.
Head, A. P.	5	40	$\frac{1}{5}$	20	12	2
Head Lat.	5	40	$\frac{1}{10}$	20	14	5
Neck	5	40	$\frac{1}{20}$	20	16	14
Shoulder	5	40	$\frac{7}{120}$	20	10	5
Elbow	5	40	$\frac{1}{40}$	20	17	34
Wrist	5	40	$\frac{1}{60}$	20	18	54
Kidney	5	40	$\frac{1}{15}$	20	10	4
Bladder	5	40	$\frac{1}{15}$	20	12	6
Hip-joint	5	40	$\frac{1}{12}$	20	12	5
Pelvis	5	40	$\frac{1}{12}$	20	12	5
Knee	5	40	$\frac{1}{30}$	20	15	19
Ankle	5	40	$\frac{1}{40}$	20	17	34
Lumbar spine	5	40	$\frac{1}{10}$	20	10	4
Teeth (slow film)	5	40	$\frac{1}{15}$	20	18	13
Teeth (fast film)	5	40	$\frac{1}{40}$	20	18	36
Chest	5	40	$\frac{1}{15}$	28	16	11

The importance of the distance of the skin from the target of the tube is well illustrated in the list of number of plates, especially in the case of kidney and bladder exposures; here the only change in the four factors is in the distance. The difference in distance is two inches, which makes a difference of two in the number of plates. This should make one exceedingly cautious when dealing with excessively large individuals whose thickness demands the maximum exposure.

For one who is not using the army factors and who has inadvertently used the wrong factors in a given case, and wishes to repeat the procedure, it is a simple matter to determine the dosage the skin has already received and then decide whether it would be safe to repeat or postpone the operation for a time.

In taking a series of plates or films, overlapping of the areas exposed must be considered even though the factors are correct and properly maintained throughout each exposure.

From the foregoing list of a number of plates it is obvious that the head, kidney, bladder, pelvis, and lumbar spine are the ones that require the

larger doses to obtain results. If a case of this kind is passed on from one roentgen-ray laboratory to another, in a comparatively short time, and standard exposures made in each place, a roentgen-ray burn may occur. Roentgenologists, and especially those who specialize in the branches in which these large doses are required to obtain good plates, would appreciate a complete roentgen-ray history as well as clinical history of these cases. By a complete roentgen-ray history is meant the time the plates were taken, the position of the patient, the factors used in making the exposures and the date of the last examination. With these data the roentgenologist could determine at once how soon it would be safe to proceed with his examination, instead of waiting three or four weeks from the date of the last exposure in order to avoid either increasing an already produced burn or adding enough more to produce one that otherwise would be a safe and sane exposure.

Erythema appears in from ten to fourteen days, so that at the end of three weeks one is safe in concluding, if the skin appears normal, that the exposure the patient has had was not sufficient to

produce an erythema. But the dose may have been of such intensity that by adding the large amount necessary for the second examination may induce an alopecia or erythema by the combined exposures. If an erythema or temporary alopecia has occurred during the third week after the first examination, it would seem advisable to wait at least six weeks from the date of the last exposure.

From a medicolegal standpoint it would seem assured that the defendant would be in a much better position to defend himself if he knew his factors and the valuation of the same in determining the cause of roentgen-ray burns.

The army factors with an interrupterless machine and a Coolidge radiator type tube whose maximum working factors are 5-inch gap and 30 ma. would mean a change from 40 ma. to 30 ma. and a proportionate increase in the time of the exposure. For example, the factors given for an A. P. Head are 5-inch gap, 40 ma. at 20-inch distance, with 12 seconds' time. To compensate for the one-quarter decrease in milliamperes, the time given in army formula (12

seconds) would equal three-quarters; one-fourth would be 4 seconds and four-fourths 16 seconds, or the time necessary to produce the same effect on the plate.

The principle involved in the adaptation of the above-mentioned radiator tube to the army formula may be illustrated by Prof. J. S. Shearer's roentgenographic formula:

$$\frac{40 \text{ ma.} \times (5 \text{ K V})^2 \times \frac{1}{5} \text{ minute}}{(20\text{-inch distance})^2} =$$

$$\frac{\overset{2}{\cancel{10}} \qquad \overset{1}{\cancel{5}}}{\cancel{40} \times \cancel{5} \times \cancel{5} \times \cancel{5}} = \frac{1}{2}$$

$$\frac{\cancel{20} \times \cancel{20}}{\cancel{4} \quad \cancel{4}^2}$$

$$\frac{30 \text{ ma} \times (5 \text{ K V})^2 \times \text{time}}{(20\text{-inch distance})^2} =$$

$$\frac{\overset{15}{\cancel{30}} \times \cancel{5} \times \cancel{5} \times T}{\cancel{20} \times \cancel{20}} = \frac{15}{8}$$

$$\frac{\cancel{4}}{\cancel{20} \quad \cancel{4}}$$

$$\frac{1}{2} \div \frac{15}{8} = \frac{1}{\cancel{2}} \times \frac{\cancel{8}^{4}}{15} = \frac{4}{15} \text{ minutes} = 16 \text{ seconds}$$

By interposing ½ mm. aluminum filter, three times the number of plates may be made, and with 1 mm. aluminum filter six times the number of plates without danger to the patient. This is based on the time necessary to produce 1½ skin units of filtered roentgen ray, using ½ and 1 mm. aluminum filter with the army factors and skin distance instead of plate distance. From the regular formula 12 seconds is the time for one plate of an A. P. Head. With a skin distance of 12 inches $2\frac{1}{10}$ plates can be taken without a filter. The time necessary to produce 1½ filtered skin units, which corresponds to ¾ unit unfiltered biologically, using ½ mm. al. is about 1 minute, 12 seconds and about 2 minutes with 1 mm. of al. Therefore, 1 minute and 12 seconds = 72 seconds ÷ 12 seconds = 6 plates, or three times the number allowed without ½ mm. al. filter. 2 minutes = 120 seconds ÷ 12 seconds = 10 plates, or 5 times the number indicated without 1 mm. al. filter.

CHAPTER III

FILTERED *X*-RAY DOSAGE

THE method of estimating filtered dosage differs from that of unfiltered in that each thickness of aluminum requires a separate standard or formula for one skin unit.

$\frac{1}{4}$ mm. aluminum

$$\frac{\text{9 in. gap 5 M A} \times \text{42 sec.}}{\text{10 in. dist.}} =$$

$$\frac{9 \times 5 \times \frac{42}{60} \quad \frac{7}{10}}{\frac{10}{2}} = \frac{\frac{63}{10}}{\frac{10}{2}} = \frac{63}{20}$$

$\frac{1}{2}$ mm. aluminum

$$\frac{9 \times 5 \times \text{1 min. 6 sec.}}{10} =$$

$$\frac{9 \times 5 \times \frac{66}{60} \quad \frac{11}{10}}{\frac{10}{2}} = \frac{\frac{99}{10}}{\frac{10}{2}} = \frac{99}{20}$$

1 mm. aluminum

$$\frac{9 \times 5 \times 1 \text{ min. } 54 \text{ sec.}}{10} =$$

$$\frac{9 \times 5 \times \frac{114}{60}\ \frac{57}{30}}{\frac{10}{2}} = \frac{\frac{513}{30}}{2} = \frac{\frac{513}{60}}{} = \frac{171}{20}$$

2 mm. aluminum

$$\frac{9 \times 5 \times 2 \text{ min. } 20 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{9} \times 5 \times \frac{140}{60}\ \frac{7}{3}}{\frac{10}{2}} = \frac{21}{2}$$

3 mm. aluminum

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{9} \times 5 \times \frac{154}{60}\ \frac{77}{30}\ \frac{231}{6}\ 2}{10} = \frac{\frac{231}{2}}{10} = \frac{231}{20}$$

4 mm. aluminum

$$\frac{9 \times 5 \times 4 \text{ min.}}{10} = \frac{9 \times \cancel{5} \times \overset{2}{\cancel{4}}}{\cancel{10}\ 2} = 18$$

5 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{9 \times \cancel{5} \times 7}{\cancel{10}\ 2} = \frac{63}{2}$$

6 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{63}{2}$$

7 mm. aluminum

$$\frac{9 \times 5 \times 7 \text{ min.}}{10} = \frac{63}{2}$$

The time factor differs from unfiltered in its action on the skin and pastille with a 6-inch gap or less when the four factors are used that produce 1 skin unit and then if the time of the exposure is doubled, other factors remaining constant, a reading of 1¼ skin units will be obtained. For each time that this process is repeated, the reading will advance one-quarter of a skin unit.

A 7-inch gap gives 1½ skin units when double the time to produce 1 skin unit is used, and then begins to advance at the rate of one-quarter of a skin unit for each exposure time thereafter.

The 8-, 9- and 10-inch gaps, with three times the time exposure for 1 skin unit, give 2 skin units, and then begin to advance at the rate of one-quarter skin unit for each exposure. The only exception to this rule is when 5, 6 or 7 mm. aluminum are used; twice the time produces 2 skin units and then advances by half units to 3.

To illustrate the above, we will give below a list of readings made and reported by us in the original article.

Gap	M A	D	T	P
6	5	10	3 min. 51 sec.	= 1 skin H
6	5	10	7 min. 42 sec.	= 1¼ skin H
6	5	10	11 min. 33 sec.	= 1½ skin H
6	5	10	15 min. 24 sec.	= 1¾ skin H
6	5	10	19 min. 15 sec.	= 2 skin H

Gap	M A	D	T	P
7	5	10	3 min. 18 sec.	= 1 skin H
7	5	10	6 min. 36 sec.	= 1½ skin H

7	5	10	9	min.	54	sec.	= 1¾	skin H
7	5	10	13	min.	12	sec.	= 2	skin H
7	5	10	16	min.	30	sec.	= 2¼	skin H
7	5	10	19	min.	48	sec.	= 2½	skin H
7	5	10	23	min.	6	sec.	= 2¾	skin H
7	5	10	26	min.	28	sec.	= 3	skin H

Gap	M A	D	T					P
8	5	10	2	min.	53	sec.	= 1	skin H
8	5	10	5	min.	46	sec.	= 1½	skin H
8	5	10	8	min.	39	sec.	= 2	skin H
8	5	10	11	min.	32	sec.	= 2¼	skin H
8	5	10	14	min.	25	sec.	= 2½	skin H
8	5	10	17	min.	18	sec.	= 2¾	skin H
8	5	10	20	min.	11	sec.	= 3	skin H

Gap	M A	D	T					P
9	5	10	2	min.	34	sec.	= 1	skin H
9	5	10	5	min.	8	sec.	= 1½	skin H
9	5	10	7	min.	42	sec.	= 2	skin H
9	5	10	10	min.	16	sec.	= 2¼	skin H
9	5	10	12	min.	50	sec.	= 2½	skin H
9	5	10	15	min.	24	sec.	= 2¾	skin H
9	5	10	17	min.	58	sec.	= 3	skin H

Gap	M A	D	T	P
10	5	10	2 min. 19 sec. = 1	skin H
10	5	10	4 min. 38 sec. = 1½	skin H
10	5	10	6 min. 57 sec. = 2	skin H
10	5	10	9 min. 16 sec. = 2¼	skin H

Distance in filtered dosage, instead of obeying the laws of light, produces double the effect at half distance instead of four times, as in unfiltered ray. To substantiate this statement, the following factors were used with 3 mm. aluminum:

Sp G	M A	D	T	P
9	5	6	7 min. 42 sec. = 2½	skin units
9	5	12	15 min. 24 sec. = 2½	skin units

A patient's wrists were placed beneath the tube, one at 6 inches' distance from the target, the other at 12 inches, both wrists being exposed at the same time. The one at 6-inch distance was withdrawn at half (7 min. 42 sec.); the other continued to full time exposure (15 min. 24 sec.) at 12-inch distance.

Ten days after the exposure, the erythema produced on each wrist was identical, thereby demonstrating that at full distance doubling the time

of half distance produces the same biological effect. This, then, established the fact that distance in filtered ray does not obey the same law as in unfiltered dosage. Hence the difference in the formula.

Unfiltered formula:

$$\frac{3 \times 3 \times \cancel{4}}{8 \times \cancel{8}\,\cancel{2}} = \frac{9}{16} = 1 \text{ skin unit}$$

Filtered formula, with 4 mm. aluminum

$$\frac{9 \times \cancel{5} \times \overset{2}{\cancel{4}}}{\cancel{10}\,\cancel{5}} = 18 = 1 \text{ skin unit}$$

Spark gap and milliamperes in filtered dosage obey the same law as in unfiltered; namely, double the gap or double the M A equals double the dose.

The above experiment on patients' wrists has been duplicated on the backs of other patients by using two areas, exposing one 7 minutes and 42 seconds and the other 15 minutes and 24 seconds with the other factors the same as a check on the findings reported on the wrists.

The employment of a formula to determine the amount of filtered dosage is not so simple as in unfiltered dosage, owing to the different thickness of the filter employed and the difference in the time factor, as pointed out above on 6-, 7-, 8-, 9-, and 10-inch gaps.

However, where aluminum is used as a filter, if one knows the factors that produce 1 skin unit with 3 mm. aluminum, it is not difficult to determine any dose where 3 mm. aluminum is used. For example, we know that 9 in. Sp G, 5 M A, 2 min. 34 sec., at 10-inch distance gives 1 skin unit with 3 mm. aluminum. How much time, with these as a standard, will it take to produce an erythema dose, namely 2½ skin units using 8-inch gap, 5 M A, at 10-inch distance with 3 mm. aluminum?

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{9 \times \cancel{5} \times \overset{77}{\cancel{154}}}{\underset{2}{\cancel{10}}} = 693 = 1 \text{ skin unit}$$

$$\frac{\not{8} \times \not{5} \times T}{\not{10}\ \not{2}} = 4$$

693 ÷ 4 = 173¼ sec. = 2 min. 53 sec. = 1 skin unit

If it takes 154 seconds with a 9-inch gap to produce 1 skin unit, it will take as many seconds to produce 1 skin unit with an 8-inch gap as 4 is contained in 693, or 173¼ sec. = 2 min. 53 sec. In order to determine the time necessary for an erythema dose (2½ skin units) we must know that an 8-inch gap requires three times the exposure for 1 skin unit (2 min. 53 sec.) to produce 2 skin units, which is 3 × (2 min. 53 sec.) = 8 min. 39 sec., and then it requires twice the time of 1 skin unit (2 = [2 min 53 sec.]) = 5 min 46 sec. added to the time for 2 skin units to produce 2½ skin units or an erythema dose. Thus 8 min. 39 sec. + 5 min. 46 sec. = 14 min. 25 sec., the time for 2½ skin units using 8-inch gap, 5 M A, and 10-inch distance.

What is the dose when 4 mm. aluminum is used

with 9-inch gap, 6 M A, 12 minutes' time at 10-inch distance? The standard 1 skin unit with 4 mm. aluminum is $\frac{9 \times 5 \times 4}{10} = 1$ skin unit. If it takes 4 minutes to produce 1 skin unit, it will take 12 minutes to produce 2 skin units, because it takes three times the time of 1 skin unit to produce 2 skin units with a 9-inch gap.

What would be the dose using 8-inch gap, 5 M A, 8-inch distance, and 10 minutes time with 3 mm. aluminum? The standard for 1 skin unit with 3 mm. aluminum is:

$$\frac{9 \times 5 \times 2 \text{ min. } 34 \text{ sec.}}{10} =$$

$$\frac{\overset{3}{\cancel{9}} \times \cancel{5} \times \cancel{60}\ 30\ \cancel{6}\ 2}{10} = \frac{\overset{77}{\cancel{154}}}{10} = \frac{\overset{231}{2}}{10} = \frac{231}{20}$$

In order to determine the dose for the factors given $\left(\frac{8 \times 5 \times 10}{8}\right)$ we must first find the

amount of time necessary to produce 1 skin unit with these factors.

$$\text{Thus } \frac{8 \times 5 \times T}{8} = 5.$$

the standard for one skin unit with 3 mm. aluminum $\left(\frac{231}{20}\right)$ divided by 5 will give the time necessary.

$$\frac{231}{20} \times \frac{1}{5} = \frac{231}{100} = 2\frac{31}{100} \text{ min.} = 2 \text{ min. } 18 \text{ sec.}$$

If 2 minutes and 18 seconds is the time required for one skin unit, with 8-inch gap, 5 M A at 8-inch distance, it will take 4 minutes and 36 seconds to produce 1½ skin units, and 6 minutes 57 seconds to produce 2 skin units, 9 minutes and 12 seconds to produce 2¼ skin units, with 48 seconds remaining. Ten minutes, then, would produce approximately a total of 2⅓ skin units.

What would be the dose at 20-inch distance instead of 10-inch, with 4 mm. aluminum, 8 minutes time?

The standard for 1 skin unit with 4 mm. aluminum is

$$\frac{9 \times 5 \times \overset{2}{\cancel{4}}}{\underset{2}{\cancel{10}}} = 18.$$

The proposed factors are

$$\frac{9 \times 5 \times \overset{2}{\cancel{8}}}{\underset{4}{\cancel{20}}} = 18.$$

Therefore, to find the dose, divide by the standard formula, $18 \div 18 = 1$ skin unit.

Therefore, double time and double distance of the respective factors of one skin unit produces the same results with the formula as with the biological reaction.

It therefore becomes necessary in order to determine dosage of *x*-rays filtered through aluminum to know at least one complete set of factors as a standard that will produce 1 skin unit with a certain thickness of aluminum. Also to remember that a 6-inch gap or less begins quartering after 1

skin unit, 7 inches after 1½ skin units, and 8, 9 and 10 inches after 2 skin units. Also that a 9-inch gap using 5, 6 or 7 mm. aluminum doubles the time of 1 skin unit equals 2 skin units, and then increases at the rate of one-half skin unit.

It has been found that the relation of the erythema dose of unfiltered and filtered *x*-ray was found to be 1 to 2 according to Holzknecht scale, namely 1¼ skin units unfiltered = 2½ skin units filtered. Assuming that these formulas and the methods given here are correct from biological results obtained, it is quite evident that the effects produced both by the unfiltered and filtered ray are controlled by laws entirely different from those determining plate dosage or intensity of light.

We believe that these methods of determining dosage are practical, providing an original Coolidge *x*-ray tube with solid tungsten target and interrupterless machine is used.

Pastille readings taken recently, using ¼, ½, 1, 2, 3, 4, 5, 6 and 7 mm. of aluminum, are indicated in the following table. Throughout these experiments, instead of the half distance pastille registering twice the amount of that at full distance we

ONE-HALF DISTANCE

Sp. G.	M. A.	D.	T.		P.
			¼ mm. aluminum		
9	5	10	42 sec.	= 1	skin unit
9	5	10	1 min. 24 sec.	= 1½	" "
9	5	10	2 min. 6 sec.	= 2	" "
9	5	10	2 min. 48 sec.	= 2¼	" "
			½ mm. aluminum		
9	5	10	1 min. 6 sec.	= 1	skin unit
9	5	10	2 min. 12 sec.	= 1½	" "
9	5	10	3 min. 18 sec.	= 2	" "
9	5	10	4 min. 24 sec.	= 2¼	" "
			1 mm. aluminum		
9	5	10	1 min. 54 sec.	= 1	skin unit
9	5	10	3 min. 48 sec.	= 1½	" "
9	5	10	5 min. 42 sec.	= 2	" "
9	5	10	7 min. 36 sec.	= 2¼	" "
			2 mm. aluminum		
9	5	10	2 min. 20 sec.	= 1	skin unit
9	5	10	4 min. 40 sec.	= 1½	" "
9	5	10	7 min.	= 2	" "
9	5	10	9 min. 20 sec.	= 2¼	" "
			3 mm. aluminum		
9	5	10	2 min. 34 sec.	= 1	skin unit
9	5	10	5 min. 8 sec.	= 1½	" "
9	5	10	7 min. 42 sec.	= 2	" "
9	5	10	10 min. 16 sec.	= 2¼	" "
			4 mm. aluminum		
9	5	10	4 min.	= 1	skin unit
9	5	10	8 min.	= 1½	" "
9	5	10	12 min.	= 2	" "
9	5	10	16 min.	= 2¼	" "
			5 mm. aluminum		
9	5	10	7 min.	= 1	skin unit
9	5	10	14 min.	= 2	" "
9	5	10	21 min.	= 2½	" "
9	5	10	28 min.	= 3	" "
			6 mm. aluminum		
9	5	10	7 min.	= 1	skin unit
9	5	10	14 min.	= 2	" "
9	5	10	21 min.	= 2½	" "
9	5	10	28 min.	= 3	" "
			7 mm. aluminum		
9	5	10	7 min.	= 1	skin unit
9	5	10	14 min.	= 2	" "

FULL DISTANCE

Sp. G.	M. A.	D.	T.		P.
			¼ mm. aluminum		
9	5	20	1 min. 24 sec.	= 1	skin unit
9	5	20	2 min. 6 sec.	= 1¼	" "
			½ mm. aluminum		
9	5	20	2 min. 12 sec.	= 1	skin unit
9	5	20	3 min. 18 sec.	= 1¼	" "
			1 mm. aluminum		
9	5	20	3 min. 48 sec.	= 1	skin unit
9	5	20	5 min. 42 sec.	= 1¼	" "
			2 mm. aluminum		
9	5	20	4 min. 40 sec.	= 1	skin unit
9	5	20	7 min.	= 1¼	" "
			3 mm. aluminum		
9	5	20	5 min. 8 sec.	= 1	skin unit
9	5	20	7 min. 42 sec.	= 1¼	" "
			4 mm. aluminum		
9	5	20	8 min.	= 1	skin unit
9	5	20	12 min.	= 1¼	" "
			5 mm. aluminum		
9	5	20	14 min.	= 1	skin unit
			6 mm. aluminum		
9	5	20	14 min.	= 1	skin unit
			7 mm. aluminum		
9	5	20	14 min.	= 1	skin unit

find that when the half distance pastille reaches 1½ skin units the full distance pastille reads 1 skin unit and when half the distance pastille reaches 2 skin units the full distance reads 1¼. The only exception to this is when 5, 6 and 7 mm. of aluminum are used. These register half the dose of full distance and formula. This agrees with the biological results.

If one will look over the list of pastille readings given with the factors for the various thicknesses of aluminum, it will be found that 5, 6 and 7 mm. of aluminum give the same readings when all the factors are constant. We, therefore, do not see the necessity of using more than 5 mm. of aluminum as a maximum without the addition of a piece of glass, leather, or wood.

A comparison of the effects produced by filtered and unfiltered ray in deep therapy and the reason for employing filtered instead of unfiltered may be explained by the fact that filtered ray gives only double the dose at half distance instead of four times. If then the skin were at half distance in filtered exposure, and the tumor at full distance, the skin could tolerate two skin units without injury and

the tumor at the same time would receive 1¼ skin units, whereas in the unfiltered treatment the skin would tolerate 1 skin unit without injury and the tumor at the same time would receive ½ skin unit if filtration of intervening tissue were eliminated.

Thus the tumor would receive five times the effect with filtered dosage that it would with unfiltered as exemplified by filtered readings of half and full distance. If this were true, perhaps the results of a deep therapy and direct action would be more encouraging. Instead of the tumor receiving five times the dose with the filtered ray as with unfiltered, biologically and according to formula determinations it receives just double the effect.

This statement of double the dose to the tumor at full distance in filtered as against unfiltered is borne out by the following experiment:

Two areas of a patient's back were exposed. One of them received a filtered erythema dose measured by the pastille, namely 2½ skin units. The other area received an unfiltered dose measured by the pastille, namely 1¼ skin units. Both

areas were identical in their appearance at the end of ten days after their exposure, thereby proving that the biological reaction of the skin in filtered and unfiltered *x*-ray is in the ratio of two to one.

Although unable to explain the reason for the changes in the amount of ray delivered at half distance in filtered roentgenotherapy, from a practical viewpoint the results explain the practicability of filtered ray for producing the maximum effect on the parts beneath the skin when compared with unfiltered dosage.

CHAPTER IV

PRINCIPLES OF *X*-RAY BURNS

FOUR areas of a patient's back were treated with the following factors for each area:

$$(1)\ \frac{3 \times 3 \times 5}{8 \times 8} = 1\tfrac{1}{4} \text{ skin unit}$$

$$(2)\ \frac{3 \times 6 \times 2\tfrac{1}{2}}{8 \times 8} = 1\tfrac{1}{4} \text{ skin unit}$$

$$(3)\ \frac{3 \times 4\tfrac{1}{2} \times 3\tfrac{1}{3}}{8 \times 8} = 1\tfrac{1}{4} \text{ skin unit}$$

$$(4)\ \frac{3 \times 9 \times 1\tfrac{2}{3}}{8 \times 8} = 1\tfrac{1}{4} \text{ skin unit}$$

The photograph of the patient taken ten days after treatment demonstrates that all the areas coincide, yet in two of them, namely, (2) and (4), the spark gap or Sp G is doubled and one-half the time taken for exposure that was given in (1) and (3) respectively. It therefore follows that if the

Sp G is doubled and the time reduced one-half, the same degree of erythema will be produced, other factors remaining constant.

From the standpoint of quality of the roentgen ray in the above experiment the formula with 6

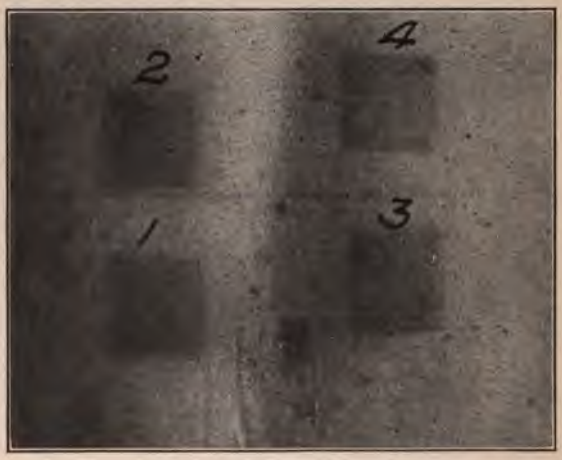

FIG. 1.—FOUR AREAS OF PATIENT'S BACK TREATED WITH THE ROENTGEN RAY

Sp G should give a very large proportion of penetrating rays as compared with the 3 Sp G and 4½ Sp G. Hence one would expect that these penetrating rays derived from the higher Sp G would

pass through the skin, and it would take much longer to produce the same erythema as was produced by the 3 Sp G and 4½ Sp G formulas which give a larger proportion of rays of low penetration, and naturally would be absorbed in the outer layers of the skin and quickly produce a burn.

By actual experiment the reverse proves true. For it took just one-half the time to produce the same biologic effect in the doubled Sp G doses (6 Sp G and 9 Sp G) as it did in the 3 Sp G and 4½ Sp G formula.

It is, then, apparent that quality of the ray and absorption of the rays of long wave have little to do with the biologic effects in the skin. On the other hand, it seems that the factor which determines this effect is solely the quantity of roentgen ray reaching the skin, for it is obvious that a high Sp G produces more rays that reach the skin than the same dose with a low Sp G or spark gap.

We published the original communication establishing the principles and practical application of this method for both filtered and unfiltered dosage in *The American Journal of Roentgenology*, Vol. IV, No. 6: 1917.

CHAPTER V

THE CAUSE OF *X*-RAY BURNS

RECENTLY we have tried out the following on the skin of a patient's back:

$$\frac{\text{MA Sp G T}}{6 \times 6 \text{ D}} = \frac{5 \times 9 \times 9/16 \text{ min.}}{6 \times 6 \text{ D}} =$$

$33\frac{3}{4}$ sec. = $1\frac{1}{4}$ skin unit = 5 H

This is an erythema dose without a filter. The filtered erythema dose using 3 mm. of aluminum is as follows:

$$\frac{\text{MA Sp G T}}{6 \text{ D}} = \frac{5 \times 9 \times 7.7 \text{ min.}}{6 \text{ D}} = 2\frac{1}{2} \text{ skin units} = 10 \text{ H.}$$

In the photograph (Fig. 2) both areas of erythema are identical. No. 1 was produced by the unfiltered erythema dose; No. 2 by the filtered erythema dose. Biologically, to all appearances, the

erythema produced in 33¾ seconds by the unfiltered ray is the same as that produced in 7 minutes and 42 seconds by the filtered.

If the voltage determines the quality of the ray, then in this experiment the voltage is the same in

FIG. 2.

both instances; the only difference is the interposition of 3 mm. of aluminum and about ten times longer exposure for the filtered dose than for the unfiltered. Here again the quantity of *x*-ray reaching the skin is materially lessened by the

aluminum, thus making the enormous difference in the time of exposure.

This dose with 3 mm. of aluminum takes a little over ten times as long to produce an erythema as it does without aluminum. In speaking of this dose some writers would say that they gave ten erythema doses. This statement without qualification is misleading. In reality the effects, so far as the skin reaction is concerned, are identical. If then the filtered and unfiltered erythemas are the same, the only difference being in the number of rays reaching the skin, thus increasing the time, why is it that a filtered dose is five or ten or any other number of erythema doses? The fact remains that biologically filtered and unfiltered erythemas are identical, as exemplified in Experiment No. 2, illustrated in Fig. 2; that 1¼ skin units unfiltered = 5 H or one erythema dose, also that 2½ skin units filtered is one filtered erythema dose.

By increasing the thickness of the filter and decreasing the spark gap the time necessary for a filtered erythema dose, namely 2½ skin units, can be progressively increased. Although decreasing

the spark gap in unfiltered dosage lengthens the time of exposure for an erythema dose, the time ratio between the lower voltages and the thickness of the filter is many times greater than those of the higher voltages. Therefore, one might select a formula with a very low voltage and be able to say that one gave forty or fifty erythema doses.

If, then, in describing the *technique of filtered dosage* we adopt 2½ skin units as the standard or an erythema dose, we can use it with the same degree of accuracy as we have the erythema dose of unfiltered dosage.

CHAPTER VI

Treatment of Focal Infection of the Throat by *X*-Ray Compared with Surgical Removal of Tonsils and Adenoids

The *x*-ray method of treating chronic focal infection of the throat, namely, tonsils and adenoids, is not only safe and permanent, but will more thoroughly and completely remove this focal infection than any other method yet devised, surgical or otherwise, and furthermore, the contraindications for operation in no way interfere with this procedure.

The technic is comparatively simple. In the average case we use a seven-inch spark gap, five milliamperes, four minutes' time, ten-inch distance, and three mm. of aluminum as filter. The patient lies face downward, head turned to the side, the position and angle of the patient and tube corresponding exactly to that employed by the roentgenologist in making a radiograph of the lower molars on an *x*-ray plate (Fig. 3). The number of treatments is usually about eight, given at in-

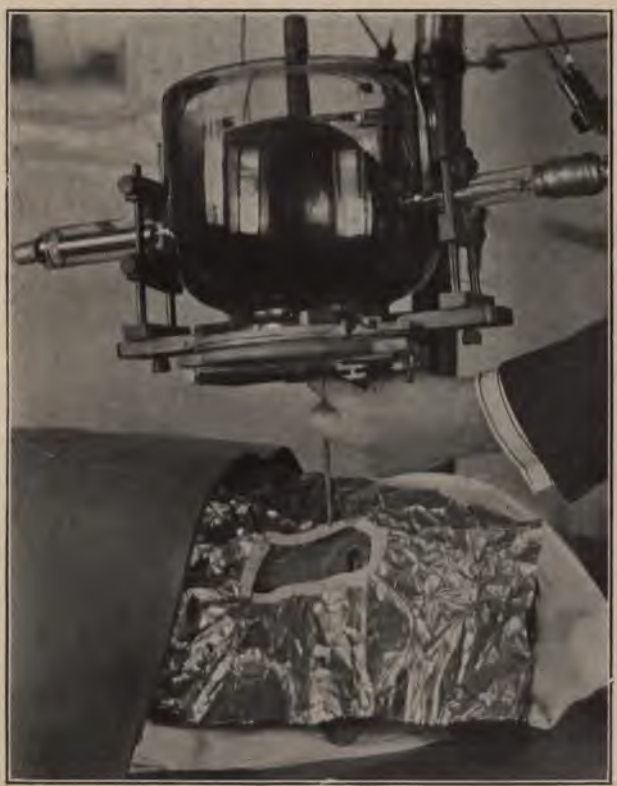

FIG. 3.—Illustrates the use of the indicator in determin- the distance and direction of the ray, showing the area exposed and pos.tion of the patient. Routine factors with this apparatus as follows: Seven inch spark gap, five milliamperes, ten inch distance, four minutes time, with three mm. of aluminum as filter.

tervals of two weeks, and both sides of the head are exposed at each treatment. A special table and board have been devised for the treatment of children.

The principle upon which this method is based might be stated as follows: Both lymphatic and embryonic tissues are more easily destroyed by the *x*-ray than any other living cell. The tonsil consists mainly of lymph tissue. The small fibroid tonsil so commonly associated with rheumatism contains lymph follicles, the greater part of which is embryonic tissue as evidenced by the mitotic figures. The embryonic tissue in the follicles of the large lymph tonsil is considerably less than is found in the fibroid tonsil. The remainder of the tissue in these follicles consists of mature lymphocytes. Therefore it is possible to use very small doses of *x*-ray to promote the absorption of the lymphatic element of the tonsil which will in no way interfere with any of the surrounding and adjacent cells or glands.

From the viewpoint of infection the shrinkage of the tonsil and lymph tissue of the lateral and posterior walls of the throat (Fig. 2) by *x*-ray will

produce a drainage and relieve the distortion of the crypts throughout the entire mucous membrane which is impossible by any known operative procedure. Out of thirty-six cases in which

FIG. 4.—This table eliminates the danger of overhead high tension wires, and is especially adapted to the treatment of children. The adult dose consists of the following factors: Five and a half inch spark gap, five milliamperes, ten inch distance, five minutes time, with two mm. of aluminum as filter. Time of exposure diminished in proportion to the age of the child.

specimens from the crypts were taken thirty-two showed an absence of hemolytic streptococcus and hemolytic staphylococcus. This coincides with the results which have so long been obtained in acne vulgaris and also the results first obtained

by Dr. Kennon Dunham, of Cincinnati, in the treatment of carbuncle. Recently Dr. Hickey, of Detroit, has carried out this treatment in a series of diphtheria carriers in which he was able to rid the throat of diphtheria baccilli in from two to four days and this occurred in eighty per cent of the cases treated.

This method, as compared with surgical removal of tonsils and adenoids, is free from serious complications. Following surgical removal one may have all the conditions which arise from circulating septic emboli; lung abscess, empyema, phlebitis, endocarditis, hemorrhage, middle ear infection and mastoiditis may also complicate recovery. In the *x*-ray treatment there are no known complications provided the technic is faithfully carried out. The permanency of the results, as well as the safety of this method, can easily be checked up by any man who in the past ten years has had a number of tuberculous glands of the neck treated by *x*-ray. Van Allen's recent report of fifty cases is most interesting and instructive. (1)

The same technique, so far as the factors are con-

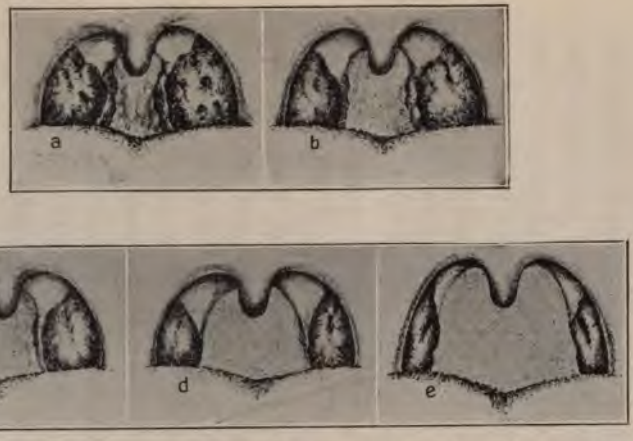

FIG. 5.—a, Tonsils before *x*-ray treatment; large, ragged; crypts contain pus; large mass of lymphoid tissue behind posterior pillars. b, Two weeks after treatment; tonsil surface smooth and clean; mass behind pillars reduced. c, Four weeks after treatment; tonsils markedly reduced; pale and smooth; no exudate on deep pressure. d, Eight weeks after treatment; small amount of exudate. e, Six months after treatment; tonsils small, normal in appearance; no exudate on deep pressure. Lymphoid tissue behind pillars practically gone. Hemolytic streptococci disappeared from throat by second week after treatment.

cerned, is used in the treatment of tuberculous glands of the neck and toxic goitre, the only difference being in the area exposed; in the goitre case we expose both the tonsil and the thyroid gland, and in the tuberculous gland, the tonsils and glands involved. Whether an infected throat has anything to do with the toxic goitre is a debatable point. However, we have seen one patient sent into the hospital with an acute follicular tonsillitis which in forty-eight hours presented all the symptoms of toxic goitre. If the infected throat or tonsil has anything to do with the action of the thyroid gland we might expect better results in these cases if the focal infection in the throat is relieved, as well as the effect of the ray on the gland itself. In tuberculous glands of the neck the removal of the focal infection in the tonsil and throat will also relieve the primary focus of infection and thus have more lasting results on the effect on the tuberculous gland.

The objections so far encountered to the *x*-ray method have been, first, the dangers of *x*-ray, namely, a burn. This is impossible if the technique prescribed is carried out. The possibility of injury

to the parotid, the thyroid, the pituitary, and other adjacent glands has been amply tested in the past ten years in which tuberculous glands of the neck have been treated by much larger doses, some of the patients receiving as high as forty doses, whereas the dose for tonsils and adenoids has never exceeded fourteen treatments in any given case in a series of nearly five hundred cases which we have treated in the past two years.

We have encountered two cases of concealed abscess of the tonsil in our series of five hundred cases, revealed by the shrinkage of the tonsil. Both patients were suffering from rheumatism and in both instances the rheumatism was relieved in the early part of the treatment. These abscesses are completely circumscribed and walled off by fibrous tissues and are therefore inert. In one of the cases the abscess ruptured and drained about three months after treatment. *The fibrous tissue remaining after x-ray treatment and the incapsulation of these abscesses point out the fact that we leave only that type of tissue which nature utilizes in her defense against infection.* This method is especially indicated in chronically infected throats

in vocalists, since the muscular reconstruction of the throat is minimum as compared with that following surgical removal of tonsils and adenoids; also in those cases associated with rheumatism, chorea, diabetes, chronic endocarditis, hemophilia, or any condition contraindicating operation.

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X-RAY TREATMENT OF TONSILS AND ADENOIDS ASSOCIATED WITH EXOPHTHALMIC GOITRE AND TUBERCULAR GLANDS

THE technique used in the treatment of tonsils and adenoids is as follows: Factors: 7″ sp. gap, 5 m. a., 10″ distance, 4 minutes' time, filtered through 3 mm. of aluminum. This exposure is given at two-week intervals, the number of exposures depending entirely on the progress of the case. So far our experience has been that the average case requires from six to eight treatments, but to say that all cases require a fixed number of treatments is about as rational as advocating a fixed number of units for all cases of diphtheria. Careful observation and examination of the throat during treatment are as essential as the factors of the technique. The dosage in children should be reduced proportionately according to the age on account of the sensitiveness of the skin.

The patient is placed on the table in the prone position, lying on the abdomen, with the head turned so that the chin comes in line with the shoulder and the *x*-ray tube centered just behind

the angle of the jaw, the opening in the lead-foil extending over an area of two inches wide from just above the external auditory meatus down to the hyoid bone. Each side is exposed for four minutes, thus giving the tonsils and adenoids a cross-fire treatment.

In chronically infected tl roats the infratonsillar nodule, lingual tonsil, and chain of lymphatics in the lateral walls, extending well up to the eustachian tube, are markedly hypertrophied and contain numerous infected crypts. The operation of dissecting out these individual crypts is necessarily tedious and impractical from the standpoint of complete removal, although some cases of rheumatism have been temporarily relieved and benefited by this procedure. It is therefore apparent that the *x*-ray effects on the follicles and crypts of the infratonsillar nodule and lymph follicles throughout the mucous membrane of the pharynx would be the same as that produced on the tonsillar tissue.

In the treatment of goitre the same factors are used with an area of exposure extending from just above the external auditory meatus down to the

lower level of the thyroid gland and transversely to the center of the middle lobe. As in the treatment of tonsils, each side is exposed four minutes, giving the gland cross-fire treatment and at the same time including the tonsils and adenoids. An examination of the throat in these cases of exophthalmic goitre almost invariably reveals chronic infection of the mucous membrane and tonsils. It is therefore essential that the infected tonsil and mucous membrane should be included in the area exposed in order to rid the patient of an infection which may be indirectly the cause of the toxic symptoms. The number of treatments varies in these cases and is regulated by the basal metabolism determinations.

The same dosage and technique may be used in the treatment of tubercular glands of the neck, the area of exposure including not only the tubercular glands, but also the tonsils and adenoids, for the reason that it is more than probable that the primary focus of infection is, or was, in the tonsil. The *x*-ray effect on the follicles and crypts of the infratonsillar nodule and the follicles throughout the mucous membrane of the pharynx

produces atrophy, due to the destruction or absorption of the immature lymphatic cells in the follicles, thus lessening the depth and distortion of the crypt and at the same time causing an eversion and evacuation of its contents. In thirty out of thirty-six cases, hemolytic streptococci and staphylococci were eliminated from the crypts four weeks after one massive dose of *x*-ray.

Investigations of a large number of cases of tubercular glands of the neck treated by *x*-ray prove not only that the treatment is harmless, but also that the tonsil and adenoids and follicles of the mucous membrane have remained atrophied. In some instances three years have elapsed since the last *x*-ray treatment; in the more severe infections of the glands of the neck it has been necessary to give as many as forty treatments. This has been done without the slightest indication of any sign or symptom of the impairment of the functions of the normal thyroid, parathyroid, pituitary, and parotid gland. *X*-ray treatment of tubercular glands of the neck has been successfully carried out for the last ten years and a review of the literature on this subject does not, so far as we

are aware, reveal a report of any case in which untoward effects have been recorded. The possibility of an *x*-ray burn is even more remote than injury to the adjacent glands provided the technique is properly carried out.

CHAPTER VII

X-RAY TREATMENT OF SKIN DISEASES

We speak of the unit as the sub erythema dose, or sufficient to produce epilation, a dose which should not produce an erythema. With the following doses the maximum effect without erythema can be obtained. (S. U. = Skin Unit.)

Adult (No Filter)

Face ½ S. U. = 2 H
Head and Joints ¾ S. U. = 3 H
Body 1 S. U. = 4 H

Aged (No Filter)

Face ¾ S. U. = 3 H
Head and Joints 1 S. U. = 4 H
Body 1¼ S. U. = 5 H

Child (No Filter)

Face ¼ S. U. = 1 H
Head and Joints ½ S. U. = 2 H
Body ¾ S. U. = 3 H

It will be noticed that for the aged you add ¼ skin unit to the dose, while for the child you

deduct ¼ skin unit, as the aged skin can stand more and the child less than the adult. The "H" in the above dose chart means Holtzknecht's Units and is given for the sake of convenience, as it will be found often in the literature, 1 S. U. = 4 H. The erythema dose is the amount of skin tolerance or sufficient amount to produce a mild erythema and should never be used unless the condition warrants.

Methods of Treatment

(1) Intensive; (2) Semi-Intensive; (3) Fractional.

The intensive treatment: Single exposure at 4 to 6 weeks' interval to same part, in quantity 1 to 2 skin units (depends upon locality of the disease and age of patient) unfiltered, or 2 to 2½ skin units filtered.

Semi-intensive: ½ skin unit unfiltered every two weeks, or 1 skin unit filtered every two weeks.

Fractional Treatment: ⅛ to ¼ skin unit once or twice a week unfiltered or ¼ to ½ skin unit of filtered rays. If twice a week ⅛, if once a week ¼ and in same porportion with filtered ray.

Always protect the hairy parts, healthy skin, testicles, and eyes with lead foil or lead rubber. Lead foil after some use and after crinkling develops small pin holes and is unsafe. There is not sufficient secondary radiation from lead or aluminum to do any harm, but it may cause an erythema, so-called static erythema. Chamois can be used to prevent this.

Varieties of X-ray Erythema

(1) Normal Erythema; (2) Static Erythema; (3) Delayed Erythema; (4) Erythema from overexposure.

Normal Erythema: Will come on from a week to ten days after treatment and last ten days to two weeks; disappearing in four weeks.

Static Erythema: Appears in from one hour to twenty-four hours and disappears in forty-eight hours. Normal erythema will usually follow. Static erythema is due to static electricity sparking from the foil to the skin. This erythema is harmless.

Delayed Erythema: Occasionally a patient who has been given an erythema dose will show no

erythema at end of ten days to two weeks but it will appear in from 4 to 5 weeks. This is a delayed reaction.

Erythema Due to Overdose: This develops in from one to three days and never disappears. If an erythema of intense degree appears in the above time, an overexposure has been given and radiodermatitis of the second or third degree may follow.

Do Not Repeat an Erythema Dose under Four to Six Weeks.

Radiodermatitis

Three Degrees (1st, 2d, and 3d).

A characteristic symptom of all degrees is Erythema. A Radiodermatitis is a reaction of the skin, or skin and subcutaneous tissues, to the *x*-ray.

1st Degree X-Ray Dermatitis: Characterized by erythema; it may vary from a faint bluish of transient nature to a deep red, lasting several days, followed by tanning.

Symptoms: Slight burning, stinging and itching; pigmentation may follow and last several

weeks or months and then disappear. Brunettes show pigmentation more than blondes, especially after several exposures.

2d Degree Dermatitis: Symptoms: Erythema, vesiculation, excoriation, exudation and frequently exfoliation accompanied by a stinging, burning pain and requiring several weeks to heal.

3d Degree Dermatitis: Symptoms: This presents all the symptoms of the 2d degree, usually ending in an indolent ulcer showing destruction of the skin and subcutaneous tissues and even involves the muscular tissue. A severe 3d degree radiodermatitis may never heal.

Sequelae of Radiodermatitis

1st Degree: Tanning, when repeated treatments are given, may be followed in six months to one year with atrophy, telangiectasia or permanent alopecia. It is well to bear this in mind and make it a rule never to give an erythema dose to an unexposed part unless the condition warrants, *e.g.*, Epithelioma, Lupus Vulgaris, Tinea Barbae. But never in Eczema, Pruritus, Acne, Sycosis Vulgaris, etc.

2d Degree: Atrophy, Alopecia, Telangiectasia and later Keratosis. Repeated erythema doses will produce all these and finally keratosis will produce epithelioma usually of the squamous cell type.

3d Degree: In this there are all the symptoms of the 1st and 2d degree dermatitis plus an ulceration that may never heal and keratosis that positively result in epithelioma. The pain of a 3d degree roentgen dermatitis is very severe.

Treatment

1st Degree: Usually none is necessary but calamine and zinc, cold cream or vaseline may be used.

2d Degree: Wet dressings, but bear in mind that there is vesiculation and exudation and that the discharge (degenerated cell products) is a powerful irritant which, whenever it comes in contact with the normal skin, will cause irritation, vesiculation and excoriation. Cover all the surrounding normal skin with a thick layer of plain vaseline before applying the wet dressing.

Wet Dressing (may be used in 2d and 3d degree radiodermatitis).

Ac. Boric 4
Sod. Chloride 10
Sod. Bi. Carb. 20 Aquae qs. ad. 100
M. Sig.: Apply locally.

Or one may use Ichthyol 1 to 3%, Ung. Zinc-Oxide qs. oz. T. or Plain Zinc Oxid 10%.

3d Degree: Same wet dressing as in 2d degree, protecting normal skin.

℞ Ichthyol 1 to 3%
Ung. zinc oxid oz. T
Anesthetin 5 to 10%
M. Sig.: Local.

Frequently it is necessary to excise and skin graft. No accidents have followed the use of the Formula Method, but it is essential to check the factors on every case.

The action of the *x*-ray upon the skin is inhibitory even to the point of destruction. You will hear of idiosyncrasy; there is such a thing as hypersensitiveness. The two words are not synonymous. If there is such a thing as idiosyncrasy certainly some case among the hundreds of children whose heads have been epilated during the past four years would have shown permanent

alopecia. When one gets disastrous results, it is due to faulty technique. There are certain conditions where the rays are more effective, *i.e.*, in the case of blond females and of the flexor surfaces and the face.

After the use of the following drugs the effect of the *x*-ray will be increased: Iodine, Iodoform, Resorcin, Oil of Cade, Tar preparations, Lotio Alba, Acid. Salicylic, B-Naphtol, Chrysarobin, Gasoline, Benzine, Scarlet Red, Sulphur, Benzoic Acid, strong mercury preparations and Balsam of Peru.

Do not use the *x*-ray for two weeks after the use of any of the above drugs. Neither must one apply any of these drugs for two weeks after the use of *x*-ray, otherwise 1 skin unit may result in a third degree burn. A case has been reported where Scarlet-Red Ointment was applied to the skin of the popliteal space, a third degree burn resulted, and healed after eighteen months. The same exposure was given on the arm, in this case, and no dermatitis resulted. In the formulas ordinarily used these drugs will act as irritants; in strong preparations they become destructive.

The *x*-ray lowers the vitality of all tissues; when this occurs in the presence of any of these drugs, they have a more powerful action on the cells, that is they become destructive even in weak preparations.

Always determine whether the patient has had recent radiographs made of the part to be treated; if so, wait until the effect has had time to disappear. The drugs that are of questionable danger and are to be used cautiously with *x*-ray: Camphor, Silver Nitrate, Chloral, Menthol, Picric Acid.

Drugs that may be used with impunity are: Phenol 2 to 4%, Calamine, Zinc Oxide, Magnesium Carbonate, Ichthyol, Bismuth preparations, Alcohol, Bay Rum, Boric Acid, Vaseline.

Method of Treating Generalized Diseases

1st Method, or Method of Choice: This is the ideal method. Divide the body in three parts: (1) Head and arms; (2) Trunk and buttocks; (3) Thighs and legs. Treat one area every other day. Divide scalp into five areas as in tinea. If disease is on face do not protect; otherwise protect face. Give ⅛ skin unit to each area on scalp.

Divide each arm into three areas anterior and three posterior. Treat each. Divide trunk into four areas anterior and four posterior. Anterior: Focus on outer border of nipple on either side. Focus on point four inches each side of umbilicus.

Posterior: Focus on each scapula and on a point corresponding to McBurney's point on the back. Focus on each buttock. Divide legs same as arms. Usually large individuals may need in addition ⅛ skin unit on lateral aspects of trunk. Though not unless the lesions here are not responding to treatment. Dosage: Scalp ⅛ skin unit not exceeding four consecutive treatments. Then allow the scalp to rest four weeks and repeat if necessary. The rest of the body may be given ¼ skin unit a week, not exceeding four months' treatment, or sixteen doses. It is advisable to protect areas not being exposed.

2d Method: When circumstances will not permit of using method number one, number two may be substituted. Treat one-half of the body twice a week. Use same dose, ¼ skin unit.

Tinea Capitis: Directions for measuring the Scalp.

The head should be closely clipped and divided into four areas as follows: for example, suppose a scalp measures from hair line to hair line, in the median line, 14 inches. Subtract ten inches, leaving four inches as a remainder. Divide the remainder by two and this gives the number of inches from the anterior and posterior hair lines. The frontal point will be two inches back of the anterior hair line, the occipital point will be two inches in front of posterior hair line; these two points, namely, the frontal and occipital, are ten inches apart; the point midway in the median line will be five inches from either of these points. This is called the crown point. From the crown point measure downwards five inches on each side for the two parietal points, then measure from the frontal point to the occipital point laterally in order that the parietal point may be exactly five inches, respectively, from the frontal and occipital points. Lines can then be drawn joining the various points which will divide the scalp into four equal triangles. Occasionally a case will be found in which the circumference of the head will measure 19 or 21 inches; in these cases

a quarter of an inch must be added to or subtracted from the five inches.

To cure this disease we remove the hair. This should be done by first accurately charting the scalp, as described above. Give each area 1 skin unit. Position of patient: on back, head turned to side; fold ear forward and fix with adhesive; treat lateral area — repeat on opposite side. Now treat frontal area. Place child on abdomen, head resting on chin, treat crown point. Now tilt head forward resting on forehead; treat occipital area. Ray must strike area at right angle.

The Kienbeck-Adamson Method: Factors, for one skin unit: 6-inch gap, 3 M. A. at 6½-inch distance and 1 minute and 19 seconds time without filter.

Always protect face and neck. When treating the crown point no protection is used, that is the only area treated without protection.

Three weeks after treatment the hair falls. Hair appears at end of 3 months, that is if your exposure has been correct. If too little, will not come out — if too much, will not come back. Extensive inflammation and suppuration may

have already produced local areas of permanent baldness. This is seen in Kerion and M. Favus. After third week a 3 to 5% ammoniated mercury ointment should be used. The child should use a cap; hair and cap should be burned to prevent spreading disease; should reinfection of scalp occur after epilation, do not repeat under six months, by which time the cells will have regained their normal resistance.

Epithelioma: Responds to one or two massive 1¼ to 2½ skin units unfiltered, especially the more superficial type. Curette away most of the lesion, especially the pearly border. Can use ethyl chloride or novocaine; ray ¼ inch beyond edge of lesion. If the epithelium be deeper and on middle-aged person give 2½ skin units unfiltered and this dose is necessary if you do not curette. In ten days erythema appears which disappears in two to four weeks. Then may repeat dose — but never repeat when there is erythema present. If involution has taken place you do not have to give as much the second time. If there are still signs of disease present repeat the original dose. Never curette any of these lesions

except a basal cell epithelioma. Do not curette a lesion at a nasolabial fold or on lower lip. They may be of the squamous cell type.

Epithelioma of Lower Lid: Responds to treatment very readily. Cut a piece of lead to fit the lesion; cover eye with lead and treat. If you can't get it all in one exposure, divide and treat each area, being careful not to overlap. Dosage: 1½ to 1¾ skin units. Repeat in four weeks.

Epithelioma of Lower Lip: Many epitheliomas of lower lip have been treated with good results without surgery. However, if there is glandular involvement have them removed. Dose: 2 skin units. This gives severe reaction; repeat in four to six weeks, giving 1½ skin units.

Epithelioma of Nasolabial Fold: Same dosage as for lip. This is often squamous and very resistant. If there is no improvement after three treatments, other treatment should be used; radium, acid nitrate of mercury (Sherwell method), electro-coagulation, or surgery. Allow plenty of margin along lesion to be radiated, as most recurrences occur from periphery of lesion.

True Tuberculosis of Skin: Lupus Vulgaris, Tuberculosis Verrucosa Cutis Scrofuloderm.

Lupus Vulgaris
1. Nodularis (ordinary type with apple jelly nodules)
2. Tumidans (rare)

This is a slowly developing disease with much fibrous tissue formation not responding readily or easily to treatment.

Tuberculosis Cutis
1. Hypertrophic (anatomical wart)
2. Verrucosa

Rapid growth responds readily to *x*-ray, may ulcerate and produce type known as Tuberculosis Ulcerosa Cutis.

TREATMENT

Lupus Vulgaris (apple jelly nodule type): Not very good results unless the fibrous capsule of the apple jelly nodule is broken up. (Satenstein has recommended the use of the dental burr for this.) In other types get good results, especially where ulcerative. Here one is warranted in giving the erythema dose starting with 1¼ skin units and increasing later to 1½ skin units if the smaller dose is not causing proper response. The heavy dose can be repeated in four weeks.

Hypertrophic Type (anatomical tubercle): Invariably responds to ray. Same treatment as in Lupus Vulgaris. The Verrucosa Cutis responds but slowly; use same method as in Lupus Vulgaris.

Scrofuloderma: This form of true tuberculosis of the skin results from breaking down and ulceration of tuberculous glands. Seen often in the cervical region of the young. Responds readily to *x*-ray with same treatment as for Lupus Vulgaris, but if glands are still involved use filtered dose.

Tuberculides (not true tuberculosis): These lesions are said to be caused by toxins from T. B. focus elsewhere in body. Lupus Erythematosus, Erythema Induratum (Bazin), Lichen Scrofuloserum, Papule Necrotic Tuberculide.

Lupus Erythematosus: Responds more when in early inflammatory stage but later you have an end result of a chronic inflammatory process, *i.e.*, atrophy and telangiectasis and as a result of caustic treatment usually scar tissue.

Erythema Induratum: Lichen Scrofuloserum and other tuberculides will respond to *x*-ray, in filtered treatment. Start with 1¼ skin units and

may go up to 1½ skin units, treating every four to six weeks.

Keloid: In this condition great care is necessary. It always requires a number of months; never give an erythema dose. The more recent the keloid the quicker and more easily it responds. Old fibrous sense lesions respond very slowly. Cut a shield of lead the exact size of keloid and use this as guide to improvement. (This will represent size of keloid at time of beginning treatment.) Under no circumstances expose any normal skin about margins. The dose is 1 skin unit (never more). Treat once a month. First effect will be thinning and flattening of the corners and angles—change in color—grows paler.

Verruca Vulgaris (ordinary warts): Shield close and give 1 skin unit. One to two treatments will frequently suffice. Some may require 1½ skin units especially these at margin of and under the nails. Pare nails close and give 1 skin unit to start with. If there is no response the dose may be increased up to 2 skin units.

Plantar Warts (corns or callosities): In this condition it is wise to shave down thin before

starting. Shield close and give 1 skin unit. Use indelible pencil to outline lesion or area you are treating and do not lap your doses if treating more than one area.

Tuberculosis Verrucosa Cutis. Scrofuloderma. Erythema Induratum (Bazin) (Tuberculide).

All will respond well to the unfiltered treatment. Start with 1¼ skin units and may go up to 1½ skin units, treating every four to six weeks. In T. B. glands it is best to use filtered ray.

Acne Keloid or Dermatitis Papillaris Capellitti: Use 1 skin unit every four weeks; takes long time. Do not produce erythema. In the Negro an erythema dose will often produce depigmentation. Good results can be obtained.

Syringocystadenoma: Perfect results can be accomplished with the *x*-ray with not more than 1 skin unit every four weeks. Why? Because there are groups of scattered lesions with healthy skin between. This skin gets as much *x*-ray as the lesions. It may take months to cure. Should there ever be any doubt about the presence of an erythema, always put off the treatment.

Granulomata: Sarcoids and granuloma annu-

larae. Shield close and give, to 1¼ skin units; Granuloma annularae may return after treatment, in some other location. Sarcoid of Boock will require more dosage, 1¼ to 1½ skin units every six weeks.

Idiopathic Hemorrhagic Sarcoma of Kaposi: Responds well with either unfiltered or filtered rays. Give 1½ to 2 skin units every four to six weeks; do not shield close. Lesions disappear very slowly; the first or second treatment relieves the pain; then color disappears and lesions gradually clear up under treatment. If the lesions are ulcerated then use filtered ray 2 to 2½ skin units. A correct diagnosis is absolutely essential for successful treatment.

Blastomycosis, Actinomycosis, Sporotrichosis: Dose is 1¼ to 1½ skin units every four to six weeks.

Ordinary Furuncle: Can be aborted in early stage by intensive dose to 1¼ to 1½ skin units.

Mycosis Fungiodes: In treating this disease care must be used because of the systemic effect of over radiation and lowering resistance. Start with ¾ skin unit and if no systemic effect is noticed, increase dose to 1 skin unit. Keloid

and Mycosis Fungiodes seem to be more susceptible to *x*-ray than ordinary conditions.

Sarcoma: Usually responds well, giant cell type responds most readily. In all types give 1 to 2 skin units every four weeks.

DISEASES TREATED BY FRACTIONAL DOSAGE

Acne Vulgaris
- Ordinary type
- Cystic type
- Pustular type
- Indurated type

Most of the cases have already been treated by other methods, so always bear in mind the contra-indications where drugs have been used; however, Phillips' Milk of Magnesia, Calamine and Glycerine as a lotion while using *x*-ray in Acne is permissible.

Position of Patient: Prone on back, place lead shield (shaped like large pair of spectacles, covering eyes and eyebrows) over eyes; secure with adhesive plaster; turn the head to one side so that chin is on line with shoulder; place lead shield over hair and ear; center tube on highest point (over zygoma); give ¼ skin unit. Repeat same process on opposite side of face. This

dosage in ordinary acne is sufficient, as the overlapping of the rays from the side exposure will suffice for the front of the face, nose, chin and forehead. However, if there are many lesions on forehead and chin an additional ⅛ skin unit every two weeks may be given to front of face. Never give more than ⅛ skin unit to front of face in Acne. Should lesions exist as one or two small isolated groups they may be treated individually. The routine treatment is ¼ skin unit every week for sixteen weeks. Treatment should be continued two to three weeks after all lesions have disappeared. In lesions on chest and back, treat as a generalized condition as already outlined. Do not look for results under six weeks. Recurrences seldom occur. Continue the dietary régime at least six months; cut down all fats, fried foods, pastries and starches and especially chocolates and sodas. Should there be an erythema or the faintest suspicion of an erythema put off one week longer. When looking for an erythema notice the skin about the eyes at the point where the protected and unprotected skin merge. Here is a good contrast.

Acne Indurata: Here the ¼ skin unit may not be sufficient. If not getting results use 3 mm. of aluminum filter and give ½ skin unit every week for two to four weeks; then ½ skin unit every two weeks for two treatments; then come back to the ¼ skin unit unfiltered weekly.

Cystic and Pustular Acne: Always evacuate the pus, and use ¼ skin unit dose as for ordinary acne. In acne indurata and pustular type the healed lesions have a reddish discoloration lasting several months after treatment. Comedones, simple or associated with acne, will disappear under *x*-ray treatment.

Psoriasis: Good results are obtained with *x*-rays. In general divide the body into the areas previously mentioned. Treat scalp as in tinea with only ⅛ skin unit and only four consecutive doses. Wait a month and then repeat. In the meanwhile continue giving all body areas ¼ skin unit every week. Remember the drugs used in treating this disease all are contra-indicated during *x*-ray treatment. Give ½ skin unit every two weeks or 1 skin unit every four weeks; this will get response when lighter doses fail. In the

chronic hypertrophic type use filtered ray, giving ½ skin unit every week or 1 skin unit every two to three weeks. Should a case absolutely not respond in a reasonable time discontinue the *x*-ray and use medication. The *x*-ray never cured a case of psoriasis; recurrences, however, are slower after *x*-ray than medication. Their recurrences can also be cleared up by the *x*-ray, and finally the *x*-ray treatment is by far the cleanest method.

Hyperidrosis and Bromidrosis: Intensive exposure can be used but it is best to treat fractionally; must use caution when raying the axillary space, as this is a flexor surface and rather sensitive. DOSE: Never more than ¾ skin unit if using intensive treatment. Fractionally use ¼ skin unit every week. Place a book beneath fingers so that they are raised on level with thenar eminences. If condition is present between fingers, give ¼ skin unit to back of fingers. A result should be seen in from four to six treatments if intensive, and ten to twelve if fractional. Feet: Do not try to treat sole of foot at one exposure. Divide into two areas. Position: Place patient

on abdomen and let ray strike sole at right angle. An additional dose may be given to back of toes.

Tinea of Feet: Use same technique and dosage as for Hyperidrosis.

Lichen Planus (Ordinary Type): Treat fractionally ¼ skin unit every week. If over entire body treat as generalized disease. Relief from the itching is first sign of improvement and may occur after second treatment. Lesions gradually clear up. Internal treatment may be used and antipruritic medication applied locally.

Pruritis Ani and Vulvae: Three methods of treatment: (1st) Intensive; (2) Semi-intensive (½ skin unit every week); and (3) Fractional. This is the most satisfactory way. Divide anal and vulval region into two areas. Give each ½ skin unit, then next dose ⅓ skin unit, then ¼ skin unit and continue with ¼ skin unit dose. The total dosage must not exceed 2 skin units. Put the patient on abdomen and have him hold buttocks apart; let the ray extend ½ inch beyond affected region. In addition to *x*-ray you can use Lotion of Calamine and Zinc Oxide or Anesthetin. Recurrence may take place in six months to one

year. When there is any demonstrable cause, fissures, etc., it should be removed.

Neurodermitis: Neurodermitis will ordinarily respond to fractional doses of ¼ skin unit every week; takes six to ten treatments. In this condition you often get a response from one treatment.

Onychia, Paronchyia and Tinea of Nail: This is a group of conditions that are difficult to treat because it is so hard to cure them without getting into trouble from overtreatment. Not over 50% will respond to ray. Dose: Intensively 1 skin unit every four weeks. Fractionally ¼ skin unit every week. The best results will be from semi-intensive treatment, ½ skin unit every two weeks.

Sycosis Vulgaris: Ordinarily yields readily to *x*-ray. If you have to epilate divide face into five areas. Center of face and neck on each side and center of neck in front. Dose: $\frac{5}{16}$ skin unit every week to each area, which equals 1¼ skin units to each area in one month. This will require caution. When not epilating give ¼ skin unit every week. Vaccines may also be used.

Technique of treatment: Center below zygoma on each side of face. Center of neck on each side. Tilt head upward and center on center of neck in front under chin. Shield area not being treated.

In skin therapy ¼ to ½ and 1 mm. of aluminum are used, occasionally 3 mm. of aluminum, depending upon the depth of the lesion to be reached. The 6-inch spark gap is quite sufficient for this thickness of aluminum. In indurated superficial lesions as acne indurata ¼ mm. of al. will suffice. ½ mm. of al. is used when you wish to go through the nails, hard plaques, as in hypertrophied lichen planus, neurodermite, or mycosis fungoides tumors. 1 mm. of al. is used in the deeper lesions as sarcoides, tuberculous glands of the neck; infiltrated tuberculosis cutis, etc. 3 mm. of al. is used when you wish to penetrate skin and muscle and to affect a deep-lying structure, as tonsil, etc. 5 mm. of al. is used for the very deepest work, as pelvic lesions, mediastinal growth or other deep-lying structures.

CHAPTER VIII

X-RAY TECHNIQUE IN THE TREATMENT OF UTERINE FIBROMATA MENORRHAGIA LEUKEMIA AND HODGKIN'S DISEASE

THE underlying principles of this method of treatment are as follows:

The effect of *x*-ray on menstruation depends upon the number of follicles that are destroyed. Amenorrhea will persist if all of them are destroyed, but if only the ripe and ripening follicles are affected menstruation will be resumed when the primordial follicles develop.

The atrophy of the tumor as well as the uterus is due to the effect on the endothelium lining of the blood vessels and the direct effect on the cells producing obliteration of the nuclei, vacuolation and finally replacement by fibrous tissue. The destruction of the follicles in the ovary no doubt has a marked effect on the tumor, uterus, and menorrhagia. Experience has taught us that the number of treatments required is influenced by the age of the patient. Those patients over forty years of age are most susceptible.

The gradual effect of *x*-ray on the uterus, ovaries, and blood vessels produces a condition which simulates the normal process of menopause. It usually requires two or three months before menopause is established, thus obviating the shock and the possibility of a complicated climacteric.

The danger of *x*-ray as compared with radium is practically negative when proper factors are used. The loss of time, discomfort, and the use of an anesthetic, required in the application of radium, together with the necessity of remaining in the hospital from one to five days, marks a distinct advantage in the favor of *x*-ray therapy.

The factors used in the average case are: 8-inch spark gap, 5 m. a., 10-inch distance, 8 minutes' time, through 3 mm. of aluminum filter. This exposure is given to three or four areas on the anterior surface of the abdomen, one over each lower quadrant and one or two over the mid-line from the pubis to the umbilicus. Three corresponding areas are exposed on the posterior or dorsal surface. The areas are exposed regularly every four weeks.

Technique for Leukemia

In the various forms of leukemia instead of exposing the spleen and the long bones to intensive treatments, we divide the trunk into twelve areas, six on the dorsal and six on the ventral surface, also each lateral cervical area. The factors used ordinarily are: 8-inch sp. gap, 5 m. a., 10-inch distance, 3 minutes' time, through 3 mm. of aluminum filter, over each area. The interval is so arranged that each area is treated once in two weeks. For example, if the patient's first treatment on Tuesday consists of the above exposure to both the lateral areas in the neck and three of the areas on the ventral surface, on Friday following the remaining three areas in the ventral surface are treated. On Tuesday of the following week three of the areas in the dorsal surface of the trunk are treated, and the areas remaining are treated on the following Friday. These exposures are given regularly until the blood count approaches normal, then the length of time of each exposure is gradually lessened and finally the interval of time between each series of treatment

is increased until the patient receives only one series of treatment in from three to six months.

By this means the patient is kept under observation and better results obtained than by giving intensive treatments until the blood picture is normal and then resuming treatment when the symptoms and blood picture indicate a return of the previous condition.

Technique of Hodgkin's Disease

This technique is the same as that followed in leukemia. The number of treatments and interval of time between each series is determined by the symptoms and condition of the patient instead of the blood count.