# THE USE OF THE X-RAY IN SURGERY.

By E. A. Codman, M. D., Boston.

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Since I began practice in December, 1895, most of my ex- [120]
perience has been obtained in the surgical wards of the Massachusetts General Hospital. It happened that in the very month in which I started practice the discovery of the X-ray was announced and within a few months I began using it. I took it up because it seemed to me likely to become a valuable aid in surgery and for the same reason I have followed its development since. What I am to say to you to-night, therefore, I trust you will take as from a surgeon rather than from an X-ray specialist. I hope that it is because I am a surgeon that I have the honor of speaking to you on the X-ray.

At the Massachusetts Hospital the X-ray is in daily, almost constant use. We are fortunate in having a skiagrapher whose sound sense and intelligent interpretation of the plates has made his opinion valuable. It is a significant tribute to the worth of the X-ray in diagnosis to see, that though this skiagrapher has no medical education as such, he is almost daily called upon to make diagnoses of the various forms of fracture or to differentiate between tubercular and syphilitic diseases of the bone, osteomyelitis and sarcoma. Probably our experience of the X-ray has been much the same as yours. I may sum it up thus: many disappointments, occasional successes, great hopes for the future. We find it especially useful in the diagnosis of fractures and bone diseases, in the localization of foreign bodies and concretions, and in the treatment of epithelioma, psoriasis and eczema.

[1] Read before the Johns Hopkins Medical Society, February 2, 1903.

[121] Occasionally it enables us to demonstrate a suspected aneurism or to determine the exact size and position of the heart, but it is not yet of much practical value in the diagnosis of thoracic diseases.

I have seen trouble caused by searching for foreign bodies which the X-ray showed very nicely. I remember a bullet in the brain which was diligently searched for. Shortly afterwards at autopsy it was found just beneath the dura. I remember a stone in the kidney which proved to be a button on the back of a nightgown. A few years ago interesting children coming to the accident room with pennies in their stomachs were admitted to the hospital; now they are allowed to pass the pennies at their homes. Occasionally, however, it is strikingly useful. In one case I remember rescuing a child from a brilliant œsophagotomy by extracting a cent impacted in the portion of the œsophagus just behind the intersternal notch. By looking with the fluoroscope I was able to see the jaws of the forceps open and close over the coin. I am satisfied that in small children coins impacted in the œsophagus can generally be removed in this way or dislodged. Incidentally I cannot speak too highly of Dr. Coolidge's method of locating and removing foreign bodies impacted in the bronchi by introducing a urethroscope through a tracheotomy wound.

We use the X-ray as a routine method in fractures. I am personally thankful that my house officer experience was in the days before the X-ray. Our house officer of to-day must leave the diagnosis to the skiagrapher. It is not fair to the patient to learn fracture pathology in the old way. I do think, however, that our greatest help from the X-ray in fractures is in learning more accurately their pathology. We see now so many skiagraphs that we jump from the look of the broken limb to the probable position and cleavage of the fragments. Thus, before the X-ray is taken, I find myself making correct clinical diagnoses of fracture of the carpal scaphoid, of the os calcis, and of certain fissures of the external malleolus, which in the old days were classed as

sprains. Fractures are set better now than they were in [121]
my day. This is especially noticeable in Colles fractures.

In the detection of stones in the kidney and ureters we have been disappointed. As yet we have not been able to keep the routine standard of excellence of the plates to a point clear enough to say positively "yes" or "no." "Yes" we can say occasionally, "no" rarely. On two occasions I have failed to locate in stout people small renal stones, which were later removed. Unless the patient is decidedly thin I should not have confidence in a negative diagnosis. I believe that the question of operation in such cases should be decided by the gravity of the symptoms or by a positive skiagraph which has been several times repeated. In the localization of ureteral stones the X-ray is especially helpful. Dr. J. W. Elliott had a brilliant case at the hospital in which a ureteral stone was located and easily and successfully removed.

Of all the cases which attend our clinic none seem so willing to keep their appointments, to wait patiently for hours, or to show themselves as those which are waiting for X-ray treatment. Perhaps there are still among you skeptics who doubt the efficiency of the X-ray as a therapeutic agent. Two years ago I was a skeptic myself and went out of my way to find philosophical and psychical excuses to explain the zeal of patients to return for treatment. I confess I cannot wholly rid myself of these excuses yet, but I have now seen some successes so brilliant that I cannot wonder that they arouse hope in the hopeless and that the poor wretch with recurrent cancer of the jaw fancies that faithful attendance on the X-ray machine will cure him as it has the man who sat next him with epithelioma of the nose.

The therapeutic X-ray work at the hospital is at present mainly done by Mr. Dodd and Dr. Vose, who are working on malignant disease for the Cancer Commission, and by Dr. Burns, who does the routine work of the skin department. Since their work will undoubtedly some day be reported in full, I will merely make a few general observations.

Though many cases of deep malignant disease have been

[121] faithfully exposed, few have essentially improved and none have been cured. There have been a few encouraging signs in some cases as relief from pain, gain in weight, shrinkage, softening, breaking down of the tumor, etc., but since these events occur in the course of untreated malignant disease the positive advantage of the X-ray can hardly be proved. On the other side, cases of epithelioma are brilliant. About a hundred have healed or are healing. Occasionally one is referred to the surgical department for excision. I am sorry to say that the present enthusiasm sends the case to the X-ray first, for I still believe that in most cases there is no Indian so good as a dead Indian. The responsibility of removal should remain with the surgeon, and he should refer it to the X-ray when contraindications to operation exist. Leaving you to look forward to the reports of Dr. Vose and Dr. Burns, I will briefly take up the more interesting of my private cases, for I do no X-ray work personally at the hospital.

Dr. J. C. Warren operated on an unusually hopeful case of cancer of the tongue in April, 1902. As far as could be seen the disease was entirely removed and the wounds healed well. I began the X-ray in May for prophylaxis and kept the floor of the mouth and sides of the neck of the patient on the edge of troublesome dermatitis until September, by which time the disease had so far recurred in the mouth and neck as to make the X-ray a mere nuisance.

Since October 4 I have treated a case of cancer of the breast, which for certain reasons had never been operated upon. I have kept the skin constantly exfoliating and at times blistered. The growth remains, so far as I can tell, practically the same.

*Note 1.*—This remains true on April 14, 1903.

In a breast case operated on by Dr. A. T. Cabot in October, 1901, there were seven spots of cutaneous recurrence on December 4, 1902, about the size of lemon seeds. These were in
[122] the skin rather than below the skin, but were not ulcerated. At the present date five have entirely disappeared and two can only with doubt be recognized. I do not mention this case

as even benefited, because of course with seven skin recur- [122]
rences the disease must also have recurred in the deeper tissues. I merely want to say that in some cases it is possible to remove by the X-ray the recurrent skin nodules.

*Note 2.*—All seven spots have disappeared and have not returned. April 14, 1903.

I have exposed without success two cases of cancer of the penis. On one case the cancer was but a quarter of an inch in diameter, but was so obstinate to X-ray treatment that an amputation was done, as there were other smaller areas of a similar nature on the glans. Possibly with more persistent and vigorous treatment I should have succeeded better. The sections from this case are shown in Figs. 1 and 2.

If I had come to speak to you in October I should have said that the only cases of malignant disease in which I had seen unequivocal improvement from treatment with the X-ray were those of epithelioma and superficial post-operative recurrence. A year ago in an article on X-ray burns I stated that there was no good evidence that the deeper tissues were affected unless the skin overlying them also was injured. I should have used this as an *à priori* argument against probable improvement in subcutaneous malignant disease.

Since then, however, I have had a case which you may take as the exception which proves the rule. On November 10, 1902, Dr. J. C. Warren referred to me a patient with sarcoma of the sterno-clavicular region on whom he had just operated. A small incision had been made and a piece of the growth removed and found by Dr. Whitney to be a round-celled sarcoma.[2] The tumor proved to be inoperable and within a

[2] At the operation on Mr. B at St. Margaret's Hospital, October 24 (S. 210-2), there was seen a diffused, infiltrating new growth over the clavicle which had grown into the muscle. The growth was white and fasciculated and to the eye presented the characteristics of a sarcoma.

Microscopic examination of the small fragment which was removed showed small, round cells in solid masses among which were occasional muscular fibres more or less degenerated, and widely separated from each other by the new growth. The cells of the new growth seemed to have a little rather homogeneous, and, in places fibrillated, tissue between them, and were traversed by very numerous, small blood vessels with distinct walls. Among the cells there were very numerous mitoses.

The structure of the growth confirms the diagnosis of sarcoma, and the type of cells places it in the round cell variety.

W. T. WHITNEY.

[122] short time I began the X-ray treatment. At that time the tumor was 5 x 2½ inches. At this date it cannot be measured, for nothing remains but a slight thickening about and behind the clavicle. The weak point of this case is that when the tumor subsided a subluxation of the clavicle was revealed. This fact suggests that the periosteum may have been torn and have formed a callous. Then too, I have seen at the hospital other cases of sarcoma faithfully followed by the X-ray and yet steadily grow worse.

I wish I could take the time to tell you of other cases—one of two small areas of facial lupus which after a six months' fight aided by curetting finally healed, only to recur again in two months; cases of psoriasis and of chronic eczema which have faded away as if by magic, and yet have recurred in other places; and two of interesting, though sad, cases of lympho-sarcoma.

In speaking of X-ray therapeutics I have purposely avoided quotations from the writings of others, believing that what you want from me are merely the things I can swear to. You have read, as I have, certain rosy articles on the use of the X-ray in the more terrible forms of malignant disease, of the disappearance of sarcoma and cancer, but all I can tell you is that at the Massachusetts Hospital we do not get such good results and in my private practice I do not get such results. I have put my best foot foremost and told you of the most wonderful cases I have had, and later I will show you a lantern slide of the most successful hospital case.

However, I am ready to stand here and say to you that the effect of the X-ray in causing the disappearance of psoriasis, chronic eczema, lupus and superficial epithelioma is little short of the miraculous. In some cases, I know that recurrence takes place, perhaps after too brief treatment. I believe, too, that though few reliable reports of success in deep cancer and sarcoma have yet appeared, considering the immense number of such cases which have been treated, the X-ray offers at least some hope and deserves an attention and dignity which has not yet been accorded it by the best of the profession.

I know that some of you will ask for a plausible theory of [122]
the action of X-rays. In answering this I will relax the strong effort I have made to stick to facts. It seems to me that the effects are due to stimulation of the nutrition of the parts rather than to destruction of the malignant tissue, because:

1. The effect often does not take place for days and sometimes for weeks.

2. From the analogy of so-called burns the primary effect is increased stimulation of the skin as evidenced by hyperæmia and exfoliation.

3. In one case of massive malignant disease of the breast which had been long and faithfully exposed no destruction of the cells was found. Degeneration in the interior of such cancers which have not been treated is often found.

4. The appearance sometimes found of shrunken cancer cells surrounded by granulation tissue may be explained by the activity of the tissue.

5. In a case of varicose eczema of the leg, which I treated, the eczema not only disappeared but the leg shrank to its normal size and its circulation became active.

6. The good effects occur chiefly in those diseases which are characterized by a disordered or indolent local nutrition, which nature when stimulated by other means has at least a chance of throwing off. For instance we all know that chronic eczema, psoriasis, lupus, rodent ulcer, epithelioma, even ulcerated cancer of the breast, may under improved conditions heal in whole or in part. Even in deep-seated malignant disease we may find cases of spontaneous absorp- [123]
tion of sarcoma, perhaps coincident with some outlandish treatment.

7. That of the above mentioned forms of disease nature is more likely to help in those in which the X-ray is most efficacious, while in cases where the malignancy of the cancer growth is great even the X-ray cannot check it.

8. That good and bad effects alike occur chiefly in the skin, the nutrition of which seems in a more delicate balance than that of the deeper tissues.

[123] I mention my choice of aiding nutrition rather than causing destruction because our choice indicates our rationale of treatment. With any modern X-ray apparatus it is possible to cause necrosis of the tissues by decreasing the distance of the tube and prolonging the time of exposure. If we are doing good by destroying abnormal tissue we want to give large doses. If we aim to stimulate we should limit our doses to their physiological effects.

My method is to expose for ten minutes at ten inches as a standard dose. To repeat this twice a week until hyperæmia appears or we reach the end of the third week. By this means, the accumulated dose at the end of the third week only reaches 60 minutes at 10 inches. Then, if necessary, to increase it, never allowing a burn of the second degree if it can be avoided, but keeping the parts hyperæmic, pigmented or exfoliating.

Since other conditions being the same the intensity varies inversely as the square of the distance from the anode, we may reduce all exposures to this unit dose by using the formula:

$$\frac{T}{D^2} \times 100 = \text{the equivalent time at a distance of 10 inches.}$$

This, of course, implies keeping the tube at a high degree of efficiency, which for most good apparatuses does not greatly differ. In most individuals slight dermatitis usually appears in from two to three weeks with my apparatus, a Kinraide coil. In one case I caused a slight dermatitis by an exposure equivalent to 15 minutes, but usually it requires 40 to 100 minutes at ten inches in added exposures. Before reaching this point psoriasis and eczema may disappear, but in my experience the tide turns in epithelioma at about the same time as dermatitis appears. To cases which do not show at least slight improvement in six weeks I should give a bad prognosis. I do not believe that it is yet justifiable to use the destructive power of X-ray to cause necrosis in the manner of the old-fashioned cancer pastes, etc. The choice between such an X-ray burn and cancer is too terrible.

Finally let us remember that cancer may arise in an X-ray

FIG. 1.

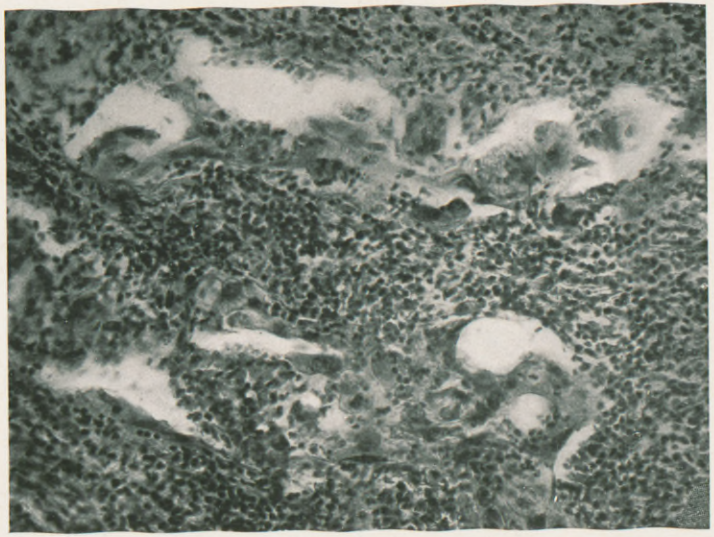

FIG. 2.

Sections taken from a case of cancer of the penis in which there were several distinct lesions, one of which had been treated much more vigorously than the others.

FIG. 1 was taken from a relatively untreated lesion and serves to show the type of cancer.

FIG. 2 was taken from the lesion which had been most treated and serves to illustrate the replacement of cancer cells by a granulation-like tissue.

Kindness of Dr. J. H. Wright.

FIG. 3.

FIG. 4.

A case of recurrent cancer of the breast before and after the use of the X-rays to illustrate the fact that though healing of a large part of the ulcerated portion has taken place, the subcutaneous growth in other places has continued to advance.
Kindness of Mr. Walter Dodd.

burn. Two such instances are on record already and one sad [123]
case has recently occurred in Boston. Cancer appeared simultaneously in the ring fingers of both hands, necessitating amputation at the first phalanges. The hands had been in a chronic state of ulceration from an X-ray burn for several years.

What information can we expect from the X-ray in cases of bone disease? This question may be partially answered *à priori* from a study of the physics of the X-ray. We cannot expect it to tell us the odor, color, sensitiveness, pain, temperature of the affected limb. No more can we expect it to give us a picture of the surface of the affected bone or of its cross or sagittal section. A skiagraph is a chart of the relative densities of the different portions of an object. More exactly it is a chart of the relative densities of substances encountered by the X-rays in their direct paths from the focal point on the anode to the photographic plate. The opacity of a substance to the X-ray varies directly with its atomic weight. Most errors in X-ray interpretation are made by looking at the skiagraph as at a cross section or as at a surface picture like a photograph. The outline is often the same, but in the skiagraph it bounds a chart of densities; in the photograph merely a picture of the surface. Therefore let us put it roughly, "Don't find fault with a skiagraph because it doesn't tell you how a bone smells."

What is the reason that pictures of the bones of the trunk in stout people are less satisfactory than of the limbs? Probably there is a little diffusion of X-ray light, but the main reason is that there is but a slight difference between the density of the total amount of substance encountered by the rays that only go through soft parts and those which go through both soft parts and bone. The contrast will stand in nearly the same ratio as the weights of equal columns of flesh to one of which a pinch of bone salts has been added. This is further complicated by other technical details as the nearness of the bone to the plate, the distance of the tube, etc. In some cases the contrast is so slight that we get no detail whatever and we must be content with merely knowing whether the bone is

[123] affected at all. In clearer pictures we may draw more complicated conclusions, e. g., that loss of substance has occurred, that new bone has been formed, that an old area of disease has become surrounded by new bone, that cavities in the bone exist, that sequestra have become isolated, and the like.

In fact we may infer with great exactness what the true pathological anatomy of the bone itself is, if we consider only the inorganic constituents of the bone. We may infer what its appearance would be if made into a dried museum specimen. But when we begin to infer the description of the organic elements we begin to make our mistakes. When we prophesy the contents of a cavity in the bone we must choose between many different forms of tissue with small atomic weight. Its contents may be cystic fluid, cartilage, pus, sarcoma, carcinoma, myeloma, gumma, osteoid tissue, tubercular granulations, or what not. In the same way cortical hypertrophy may be due to the poisons of phosphorus, syphilis, typhoid, tuberculosis, acromegaly, Paget's disease, osteo-arthropathie pneumonique and other conditions. Fortunately, however, there are often in skiagraphs certain finer details which may point more or less definitely to which one of these conditions has caused the formation of cavities or cortical thickening. For example the bone blisters in typhoid, syphilis and leprosy are not found in other diseases causing
[124] cortical enlargement. Bone abscesses, gumma, periosteal sarcoma usually show the appearance of a cavity with thick walls, while myelogenous sarcoma, myeloma, bone cysts and carcinoma show an apparent cavity with thin walls.

As another instance some of the following points might aid us in the diagnosis of a diseased leg.

In syphilis increase of new bone is the rule; in tuberculosis destruction of old healthy bone. Syphilis rarely causes the formation of a sequestrum. Tubercular sequestra are always small and poorly defined. The sequestra of osteomyelitis are generally large, well defined and resemble the cortex of the old bone. Tuberculosis almost always starts in the epiphyses and is very rare in the shaft. Syphilis is almost always in the shaft and extremely rare in the epiphysis. Cortical thick-

ening in syphilis is often very symmetrical, while in osteo- [124]
myelitis it is irregular and fantastic. In syphilis the other unsuspected long bones usually show cortical enlargement, while in osteomyelitis only one bone is the rule.

Instead of confusing you with further descriptions, however, I will show you some lantern slides, for after all practice in the interpretation of the plates is the main thing.

## Discussion.

Dr. Bloodgood.—Dr. Codman has left one very little to say except to thank him for the delightful and interesting discussion of the value of the X-ray in diagnosis and treatment.

In regard to the X-ray treatment of superficial epithelioma of the skin we have but one specimen in the surgical laboratory, which previous to its excision had been treated for some months with a Röntgen ray. Clinically the tumor was situated on the right side of the lower lip, and was about 8 x 5 mm. in diameter; it was considered to be an epithelioma. It had been present a number of months previous to the use of the X-ray. The X-ray treatment was followed for six or eight months and then discontinued. Clinically very little change was observed in the tumor. It surely did not get any larger, perhaps it got a little smaller. The tumor consisted of a small area of superficial induration at the muco-cutaneous border of the lower lip, and at one point on the mucous membrane side there was a superficial ulceration. The duration of growth from onset to the time of excision was about two years.

I was not informed of the date of the last X-ray exposure, but it was within at least four months of the time of the excision of the tumor. The tumor was removed by Dr. Finney and sent to the laboratory. It consisted of a V-shaped piece of tissue about 1.5 cm. in diameter, surrounding a small, rather circumscribed tumor at the muco-cutaneous border of the lip. On making one gross section the usual naked eye appearance of a squamous epithelioma was not definitely present. The tissues looked more finely granular, and one did not see the definite dots and lines, white in color, which in

[124] the majority of epithelioma can easily be seen, and are due to large alveoli of large squamous epithelial cells.

The first section cut and stained showed a very interesting histological picture; one could see normal skin to either side of the section, between this and extending into the deeper tissue there was a zone of tissue resembling granulation tissue. This zone of granulation tissue was not covered by normal epidermis, but by a layer two to three cells thick, of large epithelial cells. In the granulation tissue beneath this thin epithelial layer one could not recognize definitely any epithelial cells. This section therefore seemed to demonstrate what Dr. Codman has said, that the X-ray stimulates the formation of granulation tissue, and that this granulation tissue in its growth destroys the nest of epithelial cells.

February 10, 1903: Since discussing this section before the Medical Society further sections of the tumor have been cut and stained. These sections differ from the one described in that they show a definite squamous cell epithelioma. The sections, however, differ from the ordinary epithelioma in the great amount of granulation tissue between the epithelial alveoli. The first section seemed to demonstrate that perhaps the most of the epithelial alveoli had been destroyed, but further sections demonstrate that as yet the majority of the little tumor is a definite squamous cell epithelioma.