

# MORPHOLOGIC APPEARANCE OF CANCER CLINICALLY CURED BY RADIUM AND ROENTGEN RAY\*

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The reports on the result of surgical treatment of cancer cases as well as the more recent reports on radium and Roentgen-ray therapy of the disease abound in expressions "radical cure," "clinical cure" and "improvement." It is appropriate, therefore, to preface the analysis of the cases presented for this study by a correct definition of these terms.

A surgical statement that a cancer case is radically cured implies that the patient is alive and free from the disease from three to five years after the operation. The probable ultimate result of a radical operation may be inferred among others from the following study of a French surgeon, Heurtaux. During a period of thirty years he operated in 341 cases of carcinoma of the breast; 284 cases could be traced for long periods of time, and of these patients, 43.3 per cent. remained well four years after the operation and should consequently be considered radically cured. Four years later, or eight years after the operation, only 16.9 per cent. remained well and free from a recurrence. Ten years after the operation only 12.32

A recurrence of cancer, no matter how late after an operation, indicates that some tumor tissue was left behind somewhere in the organism at the operation. A radical operation for a malignant tumor means a complete eradication of all tumor tissue from the organism. An analysis of Heurtaux's writings, and

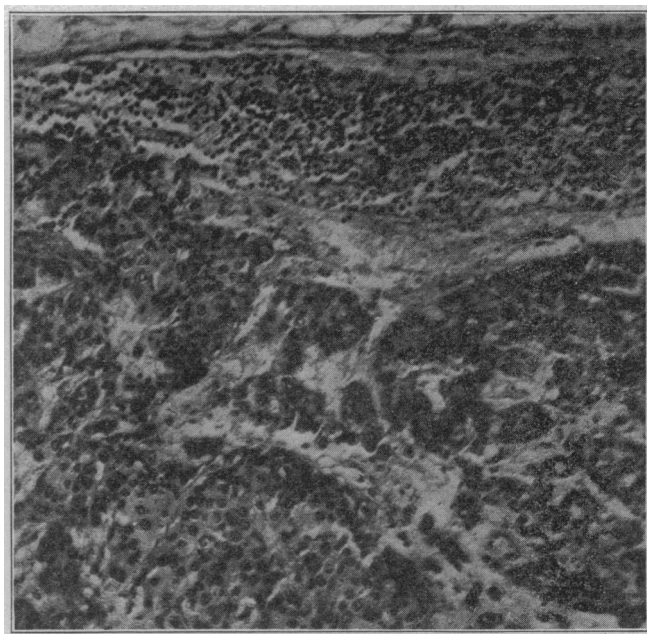


Fig. 2 (Case 1).—Metastatic carcinoma of a lymph gland.

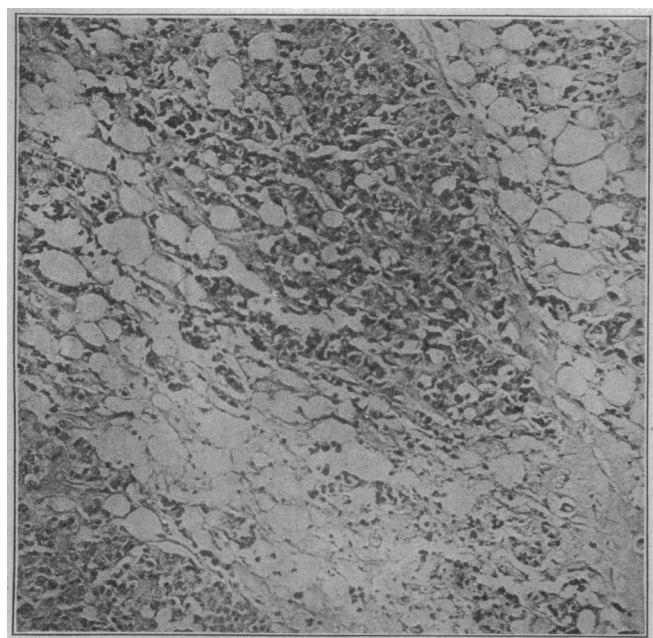


Fig. 1 (Case 1).—Scirrhus carcinoma of the breast.

per cent. remained well, fifteen years after the operation 8.1 per cent., and twenty years after the operation only 2.46 per cent. remained free from a recurrence.

\* From the Department of Cancer Research of the Montefiore Hospital and Home.

\* Read before the Section on Pathology and Physiology at the Sixty-Eighth Annual Session of the American Medical Association, New York, June, 1917.

many other similar publications, thus shows that in by far the greatest majority of cases of cancer the best surgical methods of treatment do not completely eradicate the disease and consequently do not induce a radical cure of the disease. Most frequently, then, surgery only postpones a recurrence and thus prolongs life. It is quite legitimate, nevertheless, to consider such a result a clinical cure, since the patient remains clinically well for a longer or shorter period of time, and the presence in the organism of the remnants of the malignant tumor cannot be detected by any means at our disposal. Furthermore, a clinical cure takes place even when the malignant tumor does not entirely disappear, but loses the characteristics of its malignancy, ceases to grow and invade the surrounding tissue, behaves clinically like a benign tumor and retains these characteristics for a sufficient length of time. To recapitulate: A clinical cure of cancer means a gross destruction or diminution of the size of the primary tumor with disappearance of symptoms and a well being continued for a sufficiently long time to preclude the possibility of a spontaneous remission of the disease.

An "improvement," "palliation" or "palliative improvement" must be considered the alleviation of distressing symptoms without any inhibition of the development and growth of the malignant tumor. A tracheotomy for the relief of dyspnea in carcinoma of the larynx, gastrostomy for relief of obstruction in carcinoma of the cardia, gastro-enterostomy in carcinoma of the pylorus, and colostomy in carcinoma of the colon produce such a palliative improvement, which may be followed by increase of weight and strength and temporary well being of the patient. The action of radium and Roentgen rays in arresting hemorrhage, foul discharge and relieving pain in far

advanced inoperable cancer cases also induces thereby a palliative improvement.

One of us<sup>1</sup> recently reported on several cases of inoperable carcinoma and sarcoma which remained clinically cured for a number of years by the aid of radium and Roentgen-ray therapy. The number of similar cases reported by other investigators is so great, and the therapeutic action of these radiations is so frequently satisfactory under correct and uniform conditions, that the specific action of the rays on malignant tumors does not require any further discussion. The fact that in the vast majority of cases of malignant tumors which undergo the radium and Roentgen-ray treatment a palliation or a clinical cure and not a radical cure is obtained does not detract anything from the value of the method.

The clinical effect of the radium and Roentgen rays on malignant tumors is accompanied in the great majority of cases by distinct morphologic changes in the tumor tissue. As a general rule, it may be stated that tissues consisting of less differentiated, younger cells, cells in a state of active proliferation, are most deeply influenced by the rays, and that consequently there is selective action of the rays on the actively proliferating tumor cells, as compared with the normal organ cells. The first morphologic changes which occur in carcinoma or sarcoma tissue under influence of radium and the Roentgen rays are observed in the tumor cells themselves, and are manifested by the vacuolation of the protoplasm, pyknosis of nuclei, karyolysis, and ultimately complete necrosis of the cell. These cellular changes are accompanied by a round cell infiltration which replaces the destroyed cancer cells. Subsequently this round cell infiltration is changed into dense sclerotic connective tissue poor

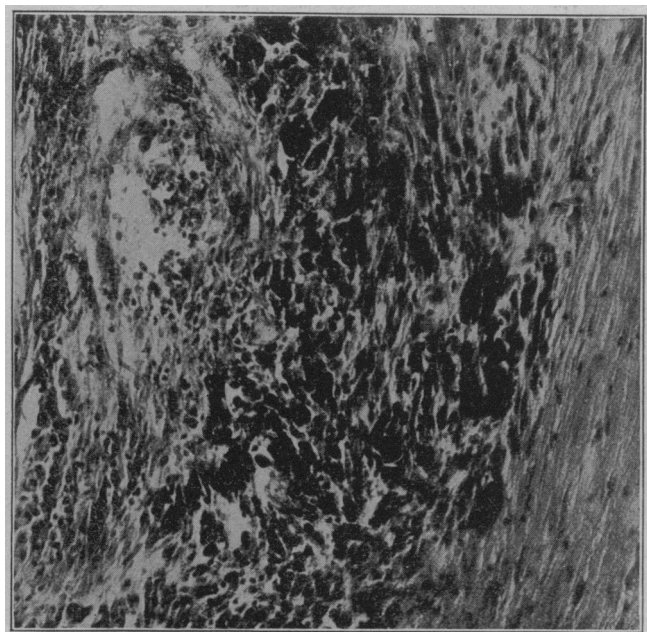


Fig. 3 (Case 2).—Melanotic cancer, primary tumor, before treatment.

in blood vessels. This connective tissue formation may become very extensive, surround islands of cancer cells, and assist in the destruction of the latter. Indeed, this new connective tissue formation is the most generally observed morphologic change in the tumor. Some observers even maintain that this con-

nective tissue formation is the only direct effect of radiation, while the destruction of the tumor cells is secondary and is due to lack of nutrition. However, this opinion is not borne out by facts. The first morphologic change noted is always the destruction of the tumor cells, and the connective tissue appears only

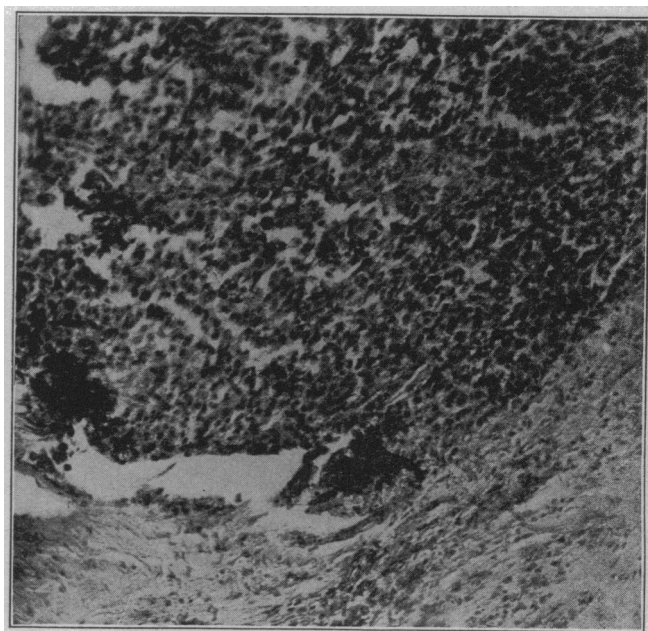


Fig. 4 (Case 2).—Melanotic cancer of the lymph gland twenty months after the beginning of the treatment.

subsequently. Moreover, in certain conditions—for instance, rodent ulcer of the skin—the epithelioma cells disappear and the ulcerated area is covered with skin epithelium without any formation of connective tissue. The assumption, on the other hand, that the formation of connective tissue is secondary to the accumulation of dead tumor cells and is analogous to formation of connective tissue around foreign bodies and particles of dead matter is also hardly tenable. Were this connective tissue formed only by the stimulus of the dead tumor cells, then the radiations would dissolve it subsequently as easily as it dissolves a keloid, for instance. However, this does not take place, and the amount of the peculiar sclerotic connective tissue usually increases with subsequent radiations.

A case of carcinoma of the sigmoid with metastatic dissemination in the peritoneum previously reported by one of us<sup>1</sup> demonstrates the importance and extent of this connective tissue formation. An exploratory laparotomy was done on the patient which revealed a carcinoma of the sigmoid and a peritoneal dissemination with minute metastatic nodules. The case was declared to be inoperable and the tumor was not removed. The patient was treated with massive doses of Roentgen rays for six months; subsequently the patient died from an acute intestinal obstruction. At the necropsy there were found in the peritoneal cavity several loops of the small intestine adherent by old adhesions to the posterior surface of the tumor mass in the sigmoid. The peritoneum was studded with numerous white plaques, varying in size from 1 to 5 mm. in diameter. Microscopic examination of a section taken through two loops of the small intestine that were firmly bound together by adhesions showed that the latter consisted of a thick layer of connective

1. Levin, Isaac: *Surg., Gynec. and Obst.*, 1915, **21**, 374.

tissue containing occasional nests of tumor cells. The peritoneal nodules were composed of dense connective tissue, with occasional minute groups of tumor cells. The amount of connective tissue in these peritoneal nodules of carcinoma was entirely out of proportion to the number of carcinoma cells present. On the other hand, the peritoneal endothelium of the sections of the wall of the small intestine adjacent to the plaques was normal and showed no connective tissue formation.

The source of the new connective tissue formed under the influence of the radium and Roentgen rays must be looked for either in the stroma of the tumor or in the round cell infiltration that closely follows the destruction of the tumor cells by the radiations. It may be stated then that while the destruction of the tumor cells is the primary phase and the formation of new sclerotic connective tissue a secondary, it is at least as important a phase in the morphologic changes which

emphysema. In August, 1915, a hard mass the size of a hen's egg was discovered in the outer margin of the right breast. The skin was adherent to the tumor, and there were enlarged glands in the right axilla. A clinical diagnosis was made of carcinoma of the breast with the involvement of the axillary glands. The general condition of the patient precluded any operative interference, and she was treated by local application of radium to the breast and axillary glands and Roentgen-rays through the chest wall. The breast tumor and the gland at first diminished somewhat in size and then remained stationary. Seventeen months later the patient died from her pulmonary condition. A complete necropsy was performed by Dr. B. S. Kline. A minute search was made for possible metastases, but none were found anywhere in the organism. The microscopic examination of the tumor of the breast showed a scirrhus carcinoma, and the lymphatic glands of the axilla were filled with solid carcinoma. Figures 1 and 2 show that morphologically both the primary tumor and the metastases in the lymph glands appeared quite malignant and did not show any changes characteristic of radiotherapy. Nevertheless, nearly a year and a half after the condition was discovered, no dissemination or distant metastases were found anywhere in the organism.

As a rule, a patient with carcinoma of the breast with the involvement of the axillary glands, if left untreated, dies in less than a year and a half from a general dissemination of the carcinoma. It is thus quite evident that in the case reported here radium and Roentgen-ray therapy inhibited the further growth and dissemination of the carcinoma tissue and transformed it, as it were, into a biologically and clinically benign type of a tumor, though it did not change its morphologic appearance.

CASE 2.—Mrs. B. K., aged 40, developed a pedunculated tumor the size of a small orange on the skin of the right supraclavicular region. The tumor was removed in March, 1915, with the pedicle. There was left after the operation an ulcerated area 1 cm. in diameter that did not heal. The microscopic examination (Fig. 3) of the tumor showed it to be a melanotic cancer. The case was then referred to one of us for radium and Roentgen-ray treatment. On examination there was observed the ulceration described above and an enlarged supraclavicular lymph gland about three-fourths inch long. Under the influence of the ray therapy, the ulcer healed and the gland at first diminished somewhat in size and then remained stationary. At present, two and one-half years after the beginning of the treatment, the patient is clinically perfectly well, and no metastatic tumors have developed anywhere. Melanotic cancer is an exceedingly malignant condition, and the average life of the patient is not more than two years. Coley and Hoguet,<sup>2</sup> who made an exhaustive study on the subject, state that the melanotic cancer in the cervical glands is especially malignant, causing death in a short time. In October, 1916, twenty months after the beginning of the treatment, the supraclavicular gland was excised for diagnostic purposes. The microscopic examination (Fig. 4) of the gland showed a morphologic picture identical with the one found in the primary tumor before the initiation of the treatment. Nevertheless, as stated above, at present, eight months after the second operation and two years and three months after the

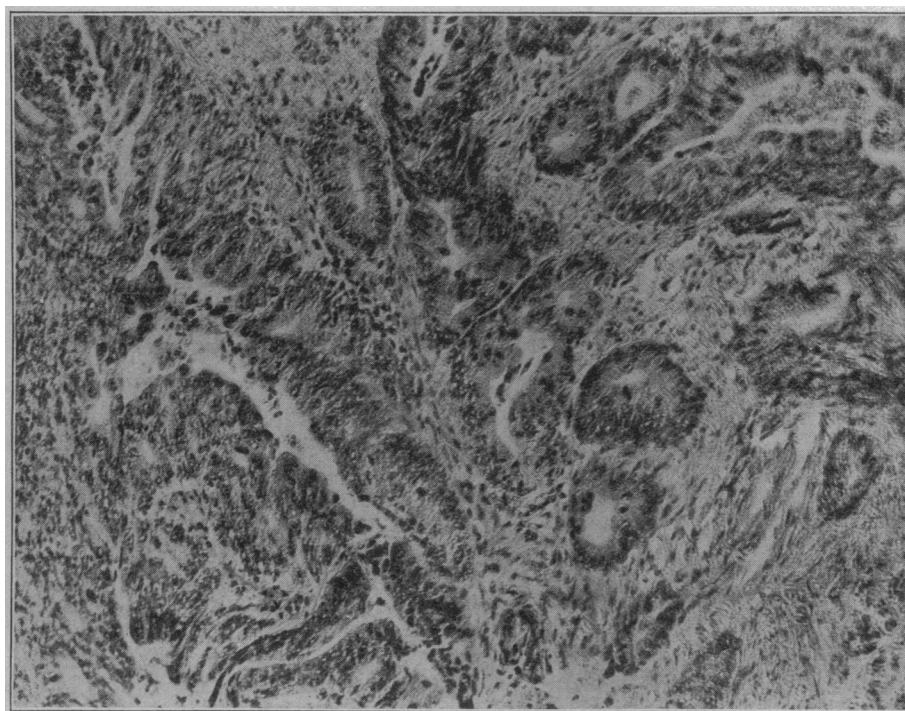


Fig. 5 (Case 3).—Adenocarcinoma of the colon, recurrent, before treatment.

take place in malignant tumors under the influence of radium and Roentgen rays. Furthermore, the microscopic study of this case of carcinoma of the sigmoid indicates the possibility that the proliferating capacity and the consequent clinical malignancy of a tumor may be inhibited under the influence of the radiations without the presence of any apparent morphologic changes in the tumor tissue. The deeper portions of the sigmoid tumor, as well as a certain number of the peritoneal plaques, showed morphologically unchanged carcinoma cells. Nevertheless, in over six months not a single one of the minute nodules found at the operation developed into a discrete secondary tumor, and the primary sigmoid tumor did not increase in size during the time.

The following series of cases, observed recently by us, present a similar condition of clinical cure without any apparent morphologic changes in the tumor tissue:

CASE 1.—Mrs. W. Y., aged 40, was admitted to the Montefiore Hospital in 1906 suffering from bronchial asthma and

2. Coley, W. B., and Hoguet, J. P.: *Ann. Surg.*, 1916, **64**, 206.

first, the patient is perfectly well and did not develop any secondary tumors anywhere. Here again the radiotherapy inhibited the proliferating power of the cancer cells and arrested the growth of the tumor without having produced any apparent morphologic change.

CASE 3.—Mr. B. G., aged 51, was operated on in December, 1915, for adenocarcinoma of the ascending colon. The tumor was radically removed and a right colostomy performed. In February, 1916, the patient was admitted to Montefiore Hospital. On admission, no recurrence of the carcinoma was found anywhere. In July, 1916, an attempt was made to close the colostomy wound by the aid of clamps, but the operation was discontinued since a recurrence was discovered at the intestinal bridge of the colostomy opening. There was felt a hard tumor mass about a cubic inch in size. The outer surface of the tumor consisted of an ulcerated area about three-fourths inch in diameter. A small piece was excised for examination, and showed microscopically an adenocarcinoma (Fig. 5). For the last ten months the patient has been undergoing Roentgen-ray treatment. He is clinically well, the tumor did not increase in size, the ulceration appears to be partly healed, and no secondary tumors or metastases developed anywhere. Recurrences in intestinal carcinoma are generally malignant, and disseminate all over the peritoneum and kill the patient very rapidly. Recently another piece was excised for examination, and the result of the microscopic study of this later specimen (Fig. 6) is very instructive. There is no direct evidence of any extensive degeneration of the cancer cells or excessive formation of new sclerotic connective tissue characteristic of radiated malignant tumors. But, unlike Cases 1 and 2, the two specimens of this case removed before and after treatment do show a certain morphologic difference. While the specimen taken before treatment shows a perfectly characteristic picture of adenocarcinoma in every field, the specimen obtained after treatment is not so characteristic, and a great many of the tubules resemble more a benign adenoma than an adenocarcinoma. These findings are somewhat difficult to explain. It is possible that the superficial, more malignant part of the tumor was destroyed under the influence of the rays. The partial healing of the ulcerated surface coincides with this assumption. The deeper portions were then inhibited by the Roentgen ray in their further malignant transformation. In any event, a clinical inhibition is quite evident in this case as well.

We have been unable to find in the literature any description of similar cases in which a clinical arrest of disease was accompanied by a complete absence of morphologic changes. Morson,<sup>3</sup> in his description of the various changes which occur in malignant tumors on exposure to the gamma rays of radium, states that there may take place a loss of the reproductive function of the cancer cell, but he does not illustrate this condition in any of his cases. On the other hand, there is a good deal of experimental evidence that elucidates the clinical and morphologic phenomena described in this presentation. Von Wassermann<sup>4</sup> reported in 1914 the results of his experiments on the action of radium on small pieces of mouse carcinoma in vitro. He has shown that the cells remain alive, but the pieces do not grow when they are subsequently inoculated in a healthy mouse. He concludes that the rays act directly on the cancer cells. However, they do not kill the cells, but impair the genueptors or the proliferating apparatus, and as a result inhibit the formation of new cells. The actual death of the cancer cell and disappearance of the tumor is produced either through the aging of the remaining cells or through the cytolytic powers of the organism. Therefore, the rays act selectively on tissues, the cells of which are rich in genueptors and proliferate rapidly. This hypothesis of von Wassermann fits in very well also with the frequently observed clinical fact

that a malignant tumor may continue to diminish in size weeks after the ray treatment was discontinued. In a recent publication on the effects of radium on tissue growth in vitro, Prime<sup>5</sup> reports very similar results. He observed that radium injures the nucleus of the cells growing in animal plasma, so that it prevents further formation of mitosis. On the other hand, it does not injure the life and functions of the cell. For instance, the outwandering of the cells from the main mass of the tumor in the culture due to ameboid motion continues with the same rapidity as in the nonradiated control cultures. The beating of a piece of a heart muscle placed in the plasma culture continues for the same length of time in the radiated as in control cultures. Identical results were obtained

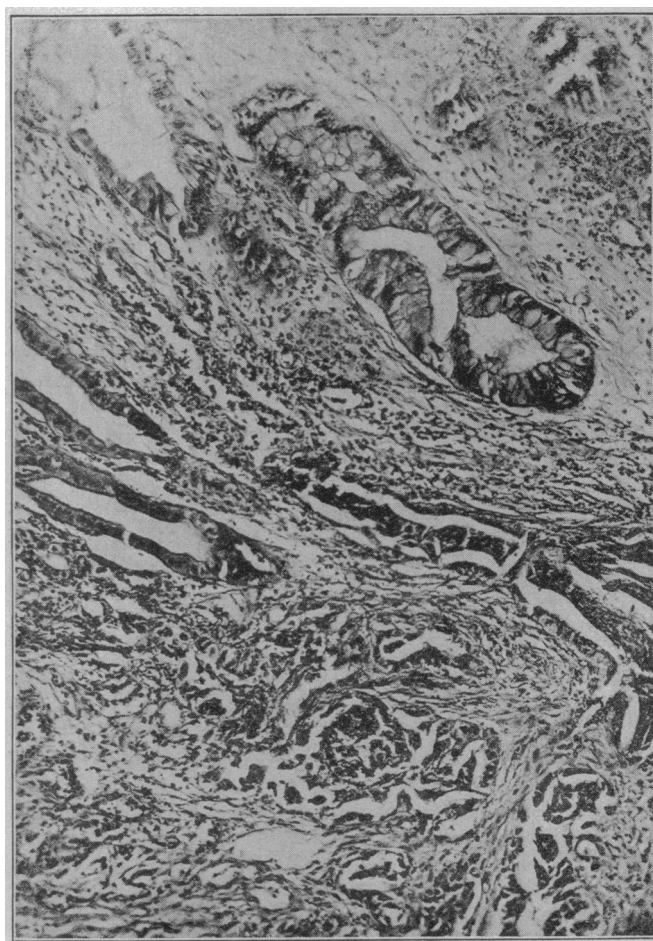


Fig. 6 (Case 3).—Adenocarcinoma of the colon after treatment.

by Halberstädter,<sup>6</sup> who studied the action of the radium rays on trypanosomes in vitro. The effect of the rays consisted in the inhibition of the infectivity of the parasites; that is, they lost their power to proliferate when introduced into a new host after having been radiated in vitro. On the other hand, the motility of the trypanosomes is not impaired by the action of the radium.

Thus the clinical investigations reported in this presentation as well as experimental studies show that the radium and Roentgen rays may impair deeply the proliferating power and consequently the clinical malignancy of cancer cells without producing any change in the morphologic appearance of the tumor. Indeed, it is quite probable that the first effect of the

3. Morson, A. C.: *Brit. Jour. Surg.*, 1915, **2**, 354.

4. Von Wassermann, A.: *Deutsch. med. Wchnschr.*, 1914, **40**, 524.

5. Prime, Frederick: *Jour. Cancer Research*, 1917, **2**, 107.

6. Halberstädter, L.: *Berl. klin. Wchnschr.*, 1914, **51**, 252.



rays on every malignant tumor consists in the inhibition of the proliferating power, in the *sterilization*, as it were, of the cancer cells. The degeneration and destruction of the cancer cells and the formation of the sclerotic connective tissue takes place subsequently, under the influence of the rays. Moreover, this cell degeneration and cell death may not be due directly to the action of the rays, but takes place in the natural course of the life cycle of the cancer cell. This cycle consists of youth, or period of development; maturity, or period of function; and the senility, or period of degeneration, which gradually leads to death. In parenchymatous organs, like the liver and the kidney, the first period is usually completed during embryonic life or at very early age. The second period continues through the whole life of the organism, and the third period is attained at the old age of the organism or near its death. The life of an individual cancer cell, on the other hand, is very short. It changes rapidly from an embryonic into an adult and then immediately into an aged, degenerated cell, and this process takes place continually irrespective of any extrinsic aid. But in a malignant tumor the majority of the cancer cells are quickly rejuvenated before they reach senility through the fact that each cancer cell changes into two young daughter cells. When the rays arrest this proliferation, then the cancer cells without any further outside aid mature and degenerate. It is interesting to note in this connection that the life of the epithelium of the skin or testicle is nearly as short as the one of the malignant tumors, and the rays act on these organs as specifically as they do on malignant tumors.

The importance of this observation is twofold. In the first place, the morphologic appearance of radiated tumor tissue is not an absolute criterion of the therapeutic effect produced by the action of the rays on the tumor. Positive finding of the changes described above as characteristic of the action of the rays is an indication of a therapeutic result. Negative findings, on the other hand, do not preclude the possibility that the tumor was influenced by the rays. Radiated and nonradiated carcinoma tissues may have the same microscopic appearance, and still the former tissue is sterilized and may have lost to a great extent its power of proliferation and consequently its clinical malignancy. In fact, the same holds true for various malignant tumors without any relationship to radiotherapy. An epithelioma may present the same microscopic picture whether it belongs to a comparatively benign, slowly growing ulcer rodens of the face or to a highly malignant epithelioma of the lip. The second point of great practical importance to be derived from this investigation is that the radium and Roentgen rays are capable in a certain number of cases of sterilizing or inhibiting the malignancy of a tumor without destroying it. It is imperative, therefore, to subject every malignant tumor to treatment by the rays, before the performance of the radical or partial operation. The same holds true of postoperative treatment. The rays may sterilize and inhibit the proliferation of the remaining cancer cells, even if they do not destroy them outright.

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#### ABSTRACT OF DISCUSSION

DR. HENRY SCHMITZ, Chicago: We must accept the dictum that the radiosensitivity of cells depends on various factors. The action of radium is direct and indirect. The direct action

causes degeneration of the cells whereby mitosis ceases. The indirect action is a systemic one which, as yet, we cannot explain.

Tumors arise not by the avidity of the tumor cells, but by a decrease of the avidity of the normal body cells. If the resistance of the host declines until it reaches a point where the carcinoma cells overpower the normal cells, then growth of the tumor follows. The question is whether it is not the systemic influence of the rays, that is, the indirect action, which brings about the cessation of growth of the tumors. The direct action of the rays on the carcinoma cells varies and depends on various factors—in the first place, on the specific character of the cells—the less differentiated the cell is the more radiosensitive will it be. It also depends on the age of the bearer of the cells. We know that the rays act very much more readily and intensely in the young than on adults. Cancers also are more malignant at this period. This behavior results from the fact that the cells of the young are more profusely nucleated; the blood supply is more abundant. In the aged, however, the nuclei become fewer and the blood vessels contract by a process of arteriosclerosis, as occurs during senility or decline of life. The carcinoma cannot grow as rapidly. The tumor also will react less powerfully to the rays. The radiosensitivity of cancer also depends on the structure of the growth. A carcinoma which is very rich in connective tissue is less easily influenced by the rays than one which consists principally of cells.

The indirect or systemic action of the radium rays may result from the splitting up of the cancer cells whereby a cell protein is liberated. This in turn is followed by a leukopenia. In patients in whom we observe a favorable reaction, this negative phase is followed by a leukocytosis and lymphocytosis. Could this fact not be construed as representing an increase in the protective powers of the host and thus explain the observation of Dr. Levin that a cessation of the growth of the tumor occurred, though apparently typical carcinoma cells were found in subsequent examinations?

DR. ALFRED WOELFEL, Chicago: In another section, in which a paper on the effect of radium was discussed, the statement was made that the effect on the pathogenesis depended on the malignancy being in a state of active mitosis, as I understood it; that no effect was to be expected from radium rays unless the cells were in a state of active mitosis or unless use was made of the caustic rays. Dr. Levin, however, explains the irradiation effect as consisting of an interruption of the proliferating power of the cells. I would like Dr. Levin to explain that a little more fully. I gather from his paper that he means that the action of the rays on the pathogenesis is not limited to the time in which the cells are in an actual state of mitosis.

DR. JAMES EWING, New York: I have often observed the condition which Dr. Levin presented and which others also have observed. I do not think, however, that any of us have wanted to commit ourselves to the view that the physical treatment of cancer can rest with the production of this state of suspended animation in cancer tissue. In practically all Roentgen-ray and radium clinics there are patients who are doing fairly well, but who still have obvious signs of the disease and whose tissue shows that the tumor cells are still in an excellent state of nutrition, and sometimes with a mitotic process going on. The disease is still there but the patient is doing very well. Yet their condition is very unsatisfactory, both to the surgeon and to the Roentgen-ray therapist.

The tendency is to do something more for these people and to attempt to destroy these cells, and the result in most instances is unfortunate. I am inclined to think that in the treatment of inoperable cases of advanced carcinoma by physical agents we shall have to come to the conclusion that all that can be expected is to bring the tumor to the state of suspended activity described by Dr. Levin; and if we can add to the duration of life by 10 per cent. of the present expectation, we shall have accomplished a great deal. It may be that physical therapy will have to leave to other methods the final solution of this problem.

As for the direct and indirect effects of physical agents, that is a matter in which there is a difference of opinion. Until we know a good deal more about the indirect effect of the rays, we had better trust to the direct effects.

DR. ISAAC LEVIN, New York: I need not reply to Dr. Schmitz's question, since Dr. Ewing has answered it. There is no direct proof of the existence of a secondary immunizing effect of the rays on the organism, and for the present we must accept only the direct action of the rays on the malignant tumor. The pathologic and clinical evidences of malignancy do not always coincide. A pathologist cannot decide from the microscopic appearance whether the specimen is derived from an ulcer rodens or an epithelioma of the lip. Clinically, on the other hand, the former is a comparatively benign condition, while epithelioma of the lip belongs to the most malignant types of cancer. The same is true of the case of melanotic cancer described in the paper; the condition surely lost its clinical malignancy since the treatment was initiated. Still the two specimens taken before and after treatment show an identical microscopic picture.

The comparative number of mitotic figures found in a microscopic specimen is also no direct indication of clinical malignancy. There are round cell sarcomas which show under the microscope a great many mitotic figures but which are clinically comparatively benign.

The first action of the rays on the cancer cells consists most probably in the inhibition of their proliferating power without any degeneration and actual destruction of the cell. The latter follows subsequently. It is true at the same time that when this stunning, as it were, of the cancer cell is not followed by its destruction, then it may ultimately recover, and a recurrence of the tumor will take place. The same process probably takes place when the tumor recurs twenty years after a radical operation.

## OILED GAUZE AND THE ABSORBING POWER OF COTTON SPONGES \*

TORALD SOLLMANN, M.D.

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"Nonadhering surgical gauze" was introduced by H. E. Fisher.<sup>1</sup> It was prepared by saturating the gauze with a soft paraffin mixture made by the addition of petrolatum, lanolin or stearic acid to paraffin. Fisher asserts especially that the blocking of the fibers prevents matting with secretions and débris; that it prevents adherence of the gauze, and that the granulations of tissue repair are not injured when the dressing is removed.

While working on paraffin bandages, I became interested in the permeability of such bandages as influenced by various waxes and oily preparations. A series of gauzes of loose and close mesh were prepared by impregnating them with paraffins of different hardness, ranging from hard paraffin to liquid petrolatum.

As the result of experiments I find that "oiled gauze," that is, gauze that is impregnated with liquid petrolatum, holds out considerable promise of usefulness. Cotton sponges wrapped in this oiled gauze absorb viscid fluids very much better than when wrapped in plain gauze; the gauze is soft and pliable; it is easily prepared, and it can be sterilized by heat after impregnation.

In the course of the investigation a loose mesh cheesecloth and a close mesh muslin were compared;

it was found that the former permits much better absorption. I also used a series of mixtures of paraffins<sup>2</sup> for impregnating the gauzes, but found that liquid petrolatum alone is superior. This oiled gauze is prepared by dipping the cloth into the liquid petrolatum and expressing out the excess.

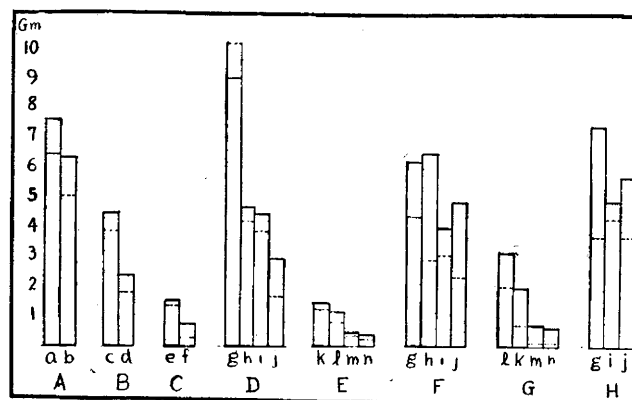
The technic of making the absorption tests was as follows:

Sponges were prepared by wrapping 1 gm. of absorbent cotton in a piece of the gauze, 12 cm. square. Egg white and egg yolk were used to simulate wound discharges. The egg white or egg yolk was placed in a flat bottom pan, in a layer perhaps 2 to 3 mm. thick; and in this were placed the sponges, which had previously been weighed. The sponges were reweighed at intervals. The results are shown in detail in the chart.

The results of the experiments may be thus summarized:

1. Sponges made of compressed cotton<sup>3</sup> absorb better than those made of loose cotton.

2. Sponges made with the cotton layers parallel to the surface absorb much better than those made with the layers vertical to the surface.



Absorption of fluid by sponges: The dotted line shows the grams of fluid absorbed in one hour, and the solid line that absorbed in twenty-four hours. A to E represent the absorption of undiluted egg white; F and G that of undiluted egg yolk, and H that of beaten egg. A, comparison of (a) compressed and (c) plain cotton, wrapped in cheesecloth; B, comparison of cotton applied (c) horizontally and (d) vertically; C, comparison of (e) cotton in muslin and (f) charcoal in muslin; the cotton, as in all these experiments, weighed 1 gm.; the charcoal pad contained 4 gm. of granular charcoal; D to H, comparison of treated and untreated gauze; (g) Stanolind cheesecloth; (h) 50 per cent. Stanolind cheesecloth; (i) plain cheesecloth; (j) Fisher cheesecloth; (k) plain muslin; (l) Stanolind muslin; (m) 50 per cent. Stanolind muslin; (n) Fisher muslin.

3. The sponges wrapped in loose mesh fabric absorb somewhat better than those wrapped in close mesh fabric.

4. Sponges filled with cotton absorb much better than those filled with powdered charcoal.

5. Sponges covered with gauze impregnated with liquid petrolatum absorb very much better than sponges covered with plain gauze.

6. Sponges covered with gauze impregnated with 50 per cent. liquid petrolatum are intermediate.

7. Sponges covered with gauze impregnated with Fisher's mixture do not absorb as well even as those covered with plain gauze.

8. The influence of oils, etc., on absorption is practically the same for loose mesh as close mesh gauze; and for egg albumin and egg yolk.

\* From the Pharmacologic Laboratory of the Western Reserve University, School of Medicine.

\* Partly supported by a grant from the Committee on Therapeutic Research of the Council on Pharmacy and Chemistry of the American Medical Association.

1. Fisher, H. E.: Nonadhering Surgical Gauze, *THE JOURNAL A. M. A.*, March 25, 1916, p. 939.

2. The following paraffins and oils were employed: hard paraffin (Parowax brand); 20 per cent. white petrolatum; paraffin (Parowax), 80 parts, white petrolatum, 20 parts (Fisher's formula); 1 per cent. naval pitch; preceding mixture with 1 per cent. naval pitch added; 50 per cent. liquid petrolatum; equal parts of paraffin (Parowax) and liquid petrolatum; liquid petrolatum (Stanolind liquid paraffin).

3. The finished sponge was compressed in an old style letter press.