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OF NEOPLASMS AND OTHER LESIONS, WITH
CLINICAL AND HISTOLOGICAL
OBSERVATIONS

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ELECTROTHERMIC METHODS IN THE TREATMENT OF NEOPLASMS AND OTHER LESIONS, WITH CLINICAL AND HISTOLOGICAL OBSERVATIONS¹

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IT is quite obvious that one who depends upon a single method in the treatment of malignant disease may not hope to obtain anything but a limited degree of success.

Experience has taught us that operative surgery, electrothermic methods, radium, and X-rays are all factors of such importance that none of them can be eliminated

Knowledge concerning the electrothermic methods is, however, not so general, owing, perhaps, to meager teachings in medical schools, to a dearth of authentic literature upon the subjects, to prejudice against any method employing electricity, to want of standardized and efficient equipment, to improper technic (hence poor results and fallacious conclusions), and to the failure



Fig. 1. A. Small round-cell sarcoma of bulbar conjunctiva and cornea.

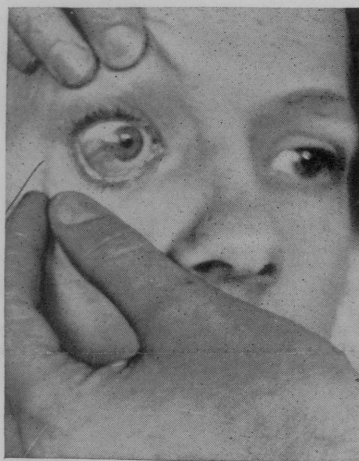


Fig. 1. B. Result of one desiccation treatment under local anesthesia. There is no perceptible scar and no impairment of vision.

from our armamentarium if the maximum of success is to be realized.

All of these methods are employed in our institution, either alone or in combination, to meet particular indications; and we have learned from experience that, if it were necessary to eliminate any one of them, we should be seriously handicapped in our work.

The status of surgery, radium, and the X-rays is well known, owing to the wide and continuous promulgation of knowledge concerning them in medical schools, and through the writings of capable exponents. Permanent recognition of these methods is assured, since their great value has been demonstrated by numerous critical tests.

of the comparatively few who do employ them correctly to report their work in a convincing manner.

Experience over a period of many years has definitely demonstrated to us the extreme importance of the electrothermic methods. We consider them as second to none and, indeed, in many emergencies superior to all.

Thus, the strong conviction that the importance of these methods of attack should be emphasized has inspired the present contribution, which is devoted to the rationale, equipment, technic, clinical and histological observations, with indications for, and contra-indications to, their employ-

¹From the Clinical and Research Departments of the William L. Clark Hospital, Philadelphia. Read before the Radiological Society of North America at the Mayo Clinic, Rochester, Minnesota, Dec. 5, 1923.

ment. The types of cases in which these methods stand supreme will be stressed, with the hope of encouraging serious consideration of their unique advantages, and

Two definite tissue changes, produced by high frequency currents, will be considered. These we classify descriptively, in accordance with the actual effects produced in



Fig. 2. A. Squamous cell epithelioma of the nose, upper lip and septum.



Fig. 2. C. Artificial nose attached to spectacle frames.

of demonstrating a sound clinical and histological basis for their employment.

To avoid confusion and that our terms may be clearly defined, we emphasize that fulguration (as originally described by de

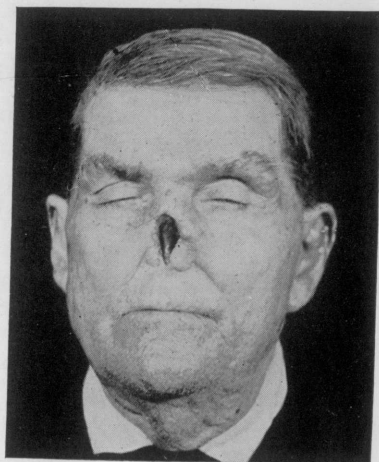


Fig. 2. B. Result of one desiccation operation under local anesthesia.

Keating Hart), thermo-cautery, galvano-cautery, and electrolysis are entirely dissimilar and, in our experience, inferior to the methods under discussion.

the tissues, as desiccation and coagulation, respectively.

The desiccation method is one by means of which benign, or malignant, growths of small, or moderate, size may be destroyed by the utilization of heat of just sufficient intensity to desiccate, or dehydrate, the tissues. The heat is produced by a monopolar high frequency current of the Oudin type, the current being conducted to the lesion by means of a steel needle, or other pointed metallic applicator. A single spark gap is employed in the circuit. The desiccation effect, as originally described, was produced by a high-tension static current transformed into a high frequency current of suitable quality by means of Leyden jars of sufficient capacity, and a resonator supplying the proper inductance. However, since the advent of the modern transformer type of high frequency machine, it has been found that desiccation can be satisfactorily produced with this latter apparatus. The principal disadvantage of the former lay in the fact that static currents, being influenced by atmospheric conditions, were often not available in humid weather. High-speed

static machines are also expensive, and occupy considerable floor space. Modern high frequency apparatus is, on the other hand, compact, comparatively inexpensive, and uninfluenced by weather conditions.

There is an impression among many that the desiccation and the coagulation methods are one and the same. This is an error, since the effects produced upon the tissue are quite different, and can readily be demonstrated both clinically and histologically. The Oudin current, by which desiccation is produced, is of relatively high voltage and low amperage; whereas, the d'Arsonval current, by which coagulation is produced, is of lower voltage and higher amperage.

A milliampere meter cannot be used to accurately measure a monopolar current. The proper current strength necessary to destroy growths of different types and sizes can be learned only by experience. The desiccation effect may be produced in the tissues by delivering the current through a short air space, by just touching the surface, or by inserting the needle more or less deeply, depending upon the degree of destruction desired.

The desiccation method is used advantageously when the lesion is localized and when good cosmetic results are not only desirable but essential. It is subject to such perfect control that an exceedingly small growth even on the cornea may be successfully treated without impairment of vision by the subsequent formation of scar tissue; a small growth on the vocal cords may, likewise, be destroyed without impairing phonation. The comparatively slight trauma to the tissues, and the mild secondary inflammation, explain, from an histological standpoint, the slight scarring and the success obtained in treating these delicate structures.

Other conditions successfully treated by the desiccation method are localized benign growths of the larynx, bladder or rectum.

Equally good results are obtained in lesions as refractory as corneal ulcers, pterygium and trachoma. Minor gynecological conditions, such as cervical erosions, urethral caruncles, etc., yield readily to desiccation



Fig. 3. Typical picture of chronic X-ray keratoses of the finger and hand, with the development of a squamous cell epithelioma. In these lesions no method has proven so satisfactory, in our experience, as the desiccation method.

treatment. Moles, papillomata, angiomas, nevus pigmentosus, leukoplakia, lupus vulgaris and erythematosis further exemplify the great variety of pathological conditions where this method may be successfully used. The desiccation method is also an important factor in the treatment of malignant lesions of the skin and mucous membranes.

It is further desirable to give special mention of this method in the treatment of hemorrhoids and infected tonsils. In the case of hemorrhoids the patient is prepared in the usual manner. A one-half of 1 per cent solution of procain is used for local anesthesia, by standard technic. The sphincter is then dilated and the hemorrhoids pulled down by means of tenaculæ and clamped in the direction of the muscle

fibers, as in the clamp and cautery operation. The desiccation current is then used to destroy the hemorrhoids. Because of the deeper sealing of the hemorrhoidal veins, hemorrhage is practically eliminated. The

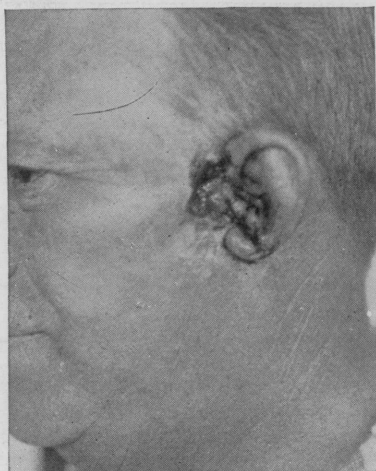


Fig. 4. A. Basal cell epithelioma involving the ear and surrounding tissues, the mastoid bone, also the ear canal almost down to the tympanum.

minor trauma to which the tissues are subjected induces but a mild local inflammation; hence, little post-operative discomfort and no unpleasant sequelæ, such as contracted cicatrix with subsequent stenosis. This method has, in our experience, simplified the treatment even in the most extensive and severe cases of hemorrhoids.

Surgical tonsils in adults, in which there is some constitutional contra-indication to surgical enucleation, can be very satisfactorily treated by the desiccation method. The operation may be performed with the patient seated in a suitable chair. The reflexes in the throat are inhibited by the topical application of a 10 per cent solution of cocaine, and the tonsils, which are not ordinarily very sensitive, are sufficiently anesthetized by the application of the same solution. A portion, or the whole, of the tonsil may be sterilized and, if desired, destroyed down to the capsule. Tonsillectomy may be done quite as radically as by any other sur-

gical method with the advantage that the patient suffers only slight post-operative discomfort. There is no contracted cicatrix, no impairment of voice, and the results are comparable to, indeed, surpass, any other

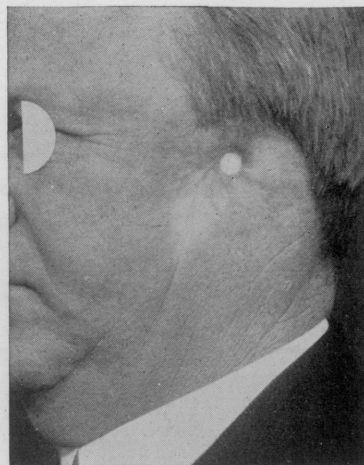


Fig. 4. B. Demonstrating refinement of control and the result of one desiccation operation under ether anesthesia. Both facial nerve and hearing were conserved.

method of which we are cognizant. An article appeared in a recent issue of the *Journal of the American Medical Association*, in which electrocoagulation was condemned in the treatment of surgical tonsils. The fact is that electrocoagulation should not have been used in the treatment of infected tonsils. Had the writer been familiar with results obtained with the milder desiccation method, he would have been as enthusiastic over the good results thus obtained as he was severely critical of the others.

Coagulation is produced by a bipolar high frequency current of the d'Arsonval type, utilizing a multiple spark gap. It is more penetrating and intense than the desiccation method and, in accessible locations, is utilized to destroy larger growths, even those involving bone.

There are many variations of technic in the application of this method to suit the requirements of the individual case. These

cannot very well be described, but must be learned from practical experience. It may be stated, however, that the active electrode should always be pointed. Steel sewing needles of various lengths may be em-

curved, so as to be adapted to particular anatomic locations. Since the effect of high frequency currents is entirely thermic, and not electrolytic, it matters not what particular metal is used. As it is impossible to



Fig. 5. A. Large round-cell sarcoma involving the face, the antrum, the malar bone, the floor of the orbit, the ethmoid, as well as all the tissues within the orbit.

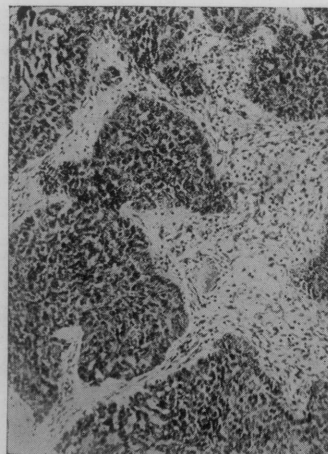


Fig. 5. B. Photomicrograph of section taken from this lesion.



Fig. 5. C. Result of one coagulation operation under ether anesthesia. Artificial features by the sculpture method are very satisfactory in similar cases. (In our opinion this is the type of lesion in which the coagulation method stands supreme. No other method could be employed so successfully.)

thoroughly insulate these electrodes, care must be taken that only such tissues as are undergoing treatment shall be touched. The indifferent electrode, which is necessary in this method, may be of any material that will conduct electricity, such as a metallic plate, or, preferably, a moistened asbestos pad. This should be placed in close contact with the skin of the patient's back. Both the active and indifferent electrodes are connected by insulated wires to either side of the d'Arsonval winding of the high frequency machine. Good contact in all the circuit connections is of great importance. A meter should be connected in this circuit as a guide to the current strength employed, which varies from about 200 to 2,500 milliamperes, according to the size of the growth to be treated. The meter is, however, not an infallible guide in estimating the action of the current, since the reading is also influenced by the size of the patient under treatment, or, in other words, by the amount of resistance in the circuit.

Doyen's method of coagulation consisted in the use of a blunt metallic electrode upon the growth, and of another of the same, or larger, size, at some point near the growth.

ployed; if still greater length is required, steel knitting needles, or stiff wire cut to any length, may be used, either straight or

It has been found, however, that the control by this technic is imperfect, and experience has taught us that the pointed active, and the large passive, electrode is a superior method of application. While the current

serting the needle into the tissues to the desired depth. Unlike the heat generated by these high frequency currents, that produced by the actual cautery is comparatively superficial in action. The former is

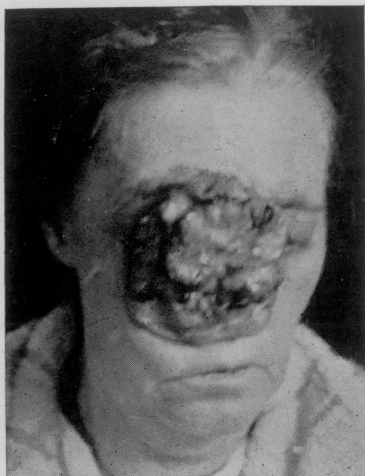


Fig. 6. A. Very advanced basal cell epithelioma involving the tissues of the face, nose, septum, antrum, malar bone, whole orbit, ethmoid, frontal sinus, extended to the inner canthus of the left eye.

is passing, the needle may either touch the surface of the growth, or be inserted into it, depending upon the depth of destruction desired. In pedunculated growths, a metal snare may be used to advantage as the active electrode. As already stated, the d'Arsonval current, by which coagulation is produced, is of relatively low voltage and high amperage. If a short air space intervenes between the growth and the needle, the current will be conducted to the tissue in the form of convective sparks which sometimes approach the intensity of a flame, depending upon the frequency of the oscillations in the current. Under such circumstances the coagulation will be superficial. On the other hand, if the active electrode remains in contact with the growth, heat will be generated in the tissues without the production of sparks. Under these conditions the tissues will be deeply coagulated, the actual depth depending upon the duration of the application. Better control of this can, however, be accomplished by in-

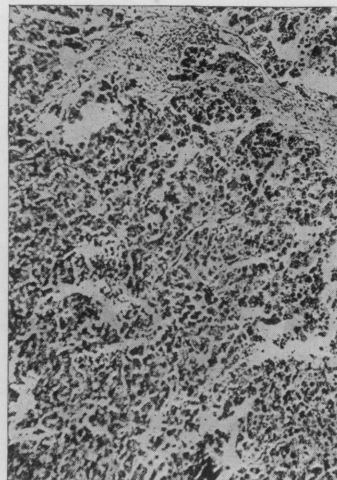


Fig. 6. B. Photomicrograph of section taken from this lesion.

generated within the tissues by their resistance to the current, while the latter is merely transmitted by contact.



Fig. 6. C. Showing the result of one coagulation operation under ether anesthesia. Again as in Fig. 5 A, B, C, the coagulation method was particularly indicated and the same result could not be accomplished by any other method.

Whether employing the desiccation or the coagulation method, the aim should be to destroy the growth at a single operation.

The devitalized tissue should, as a rule, be immediately removed either by excision or curettage, which may usually be accomplished without hemorrhage. If necessary, the base may then receive further treatment.



Fig. 7. Showing the result of a coagulation operation upon a very advanced basal cell epithelioma involving the upper lip, nose, septum, antra, ethmoid, frontal sinus and the left orbit.

When, however, the mucous surfaces are involved, owing to the greater danger of secondary hemorrhage in these localities, the destroyed tissue is, with few exceptions, allowed to slowly separate. Bone which has been treated will sequestrate in about six weeks if a current of sufficient intensity has been employed. If important blood vessels are implicated, it is a safe procedure to ligate them preliminary to treatment.

In dealing with localized, benign or malignant, lesions, the superiority of the electrothermic methods over radiation treatment is shown by definite histological changes, and by comparison of permanent clinical results. With electrothermic methods the diseased tissue, only, is destroyed, conserving the vitality of the surrounding normal structures. Subsequent treatments, should they be necessary, offer equally good prospects of success as though the tissue had not received previous treatments. On the other hand, with radiation treatment of sufficient intensity to influence a malignant

growth, it is impossible not to lower the vitality of the surrounding normal tissue, to a certain extent, and, in case of recurrence, little more can be hoped for from further radiation treatment, owing to the resulting fibrous changes. This is a fact well known to radiologists. Owing to these resulting changes, radiation treatment should not be used in conjunction with electrothermic methods in localized, benign or malignant lesions. There are many cases in which the electrothermic methods are not applicable and where radiation treatment is preferable, but our experience has been such that we feel very strongly that the electrothermic methods alone should be used in the type of lesion mentioned.

High frequency machines, as devised by different manufacturers, vary greatly in construction; hence, there is a corresponding variety in the quality of the currents produced. The thermic intensity is often too great, or too little, and an undesirable faradic effect, producing shocks and contraction of the tissues, is experienced when improperly constructed machines are used. This want of standardization is unfortunate, since, to produce the desiccation or coagulation effect under the best conditions, a very accurate balance must be maintained between the voltage and the amperage, and, also, between the capacity, inductance, and the resistance. Thus, different operators, employing different types of apparatus, may obtain different results. A machine giving a satisfactory therapeutic current may not be suitable for good surgical work. We have, for example, found it necessary to have machines constructed according to definite specifications to enable us to obtain the various factors necessary for our particular requirements. However, even with a machine constructed on correct lines, the difficulty of application lies principally in the acquirement of a proper technic. Much harm can be done by an operator without practical knowledge of the various factors involved. This warning is timely, since a considerable number of cases come under our observation that have been improperly

treated with high frequency currents. We have also heard these methods condemned by capable surgeons who have employed them, but, upon studying their technic, it has been easy to comprehend the reasons

the face, eyelids, etc., even though extensive, and with involvement of bone, may be so thoroughly treated by the desiccation or coagulation method that recurrences are infrequent. This conclusion has been reached

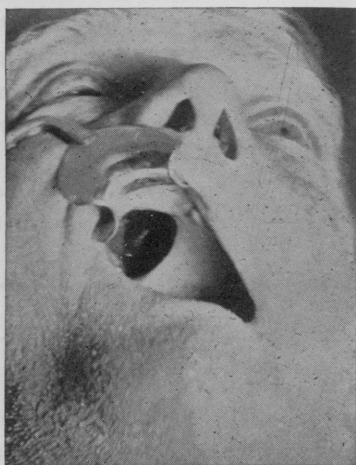


Fig. 8. A. Demonstrating result frequently obtained in carcinoma of the hard palate, alveolus and antrum by the coagulation method.

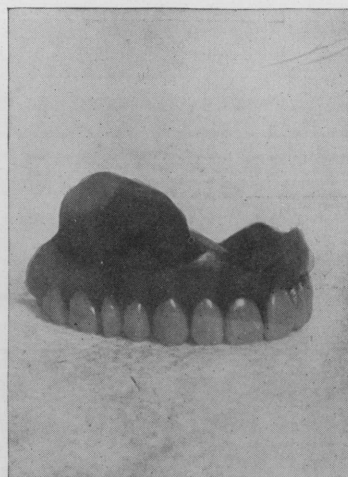


Fig. 8. B. Denture, preventing food from entering the antrum and assuring normal speech.

for their dissatisfaction with the results obtained. One who sincerely studies these methods cannot fail to be impressed with their merits.

Electrothermic methods can be best practiced only by those who have had surgical training and experience. They are quite as surgical in practical application as operative surgery, requiring the same precise knowledge of anatomical landmarks, and the same surgical judgment, that every good operator must have. The probable reasons for the apathy that exists in regard to these methods are, that surgeons do not realize their potency, and that those who use them without surgical accomplishments frequently fail in their practical application.

The efficiency of these methods is increased in some cases by the judicious combination of operative surgery, radium, and the X-rays. The electrothermic methods should be used alone, only in localized tumors of a type which do not tend to metastasize. The basal cell type of epithelioma occurring on cutaneous surfaces, such as

from the careful observation of the results of such treatment in over three thousand cases of this type.

In localized squamous cell epitheliomata on cutaneous surfaces, or mucous membranes, the results obtained are almost as good as in the basal cell type. However, when the growth is no longer localized and metastasis has occurred, other methods must be used in addition. A fair measure of success is obtained even in these cases. The grading of tumors according to Broder's method gives some indication as to prognosis, and has an influence on the choice of treatment.

Electrothermic methods are peculiarly adapted to the treatment of localized malignant growths occurring in any part of the oral cavity. In the treatment of growths of the urinary bladder, larynx, etc., suitable endoscopes must be employed to render the growth accessible for treatment. The choice between local or general anesthesia is governed by the same principles as in operative surgery.

As an example of an operation by the coagulation method, amputation of the tongue will be described. If the case is far advanced with considerable general emaciation, it is our practice to do a preliminary

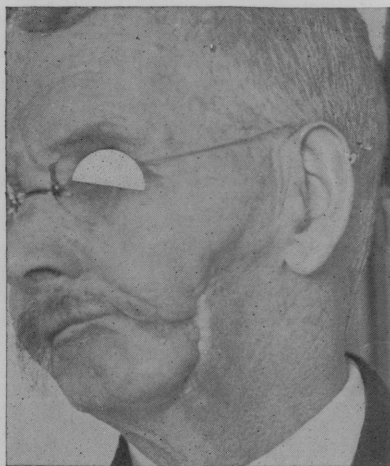


Fig. 9. Illustrating result obtained in extensive squamous carcinoma involving the buccal surface, extending through the cheek and most of the lower jaw, with metastasis to the cervical glands. The initial lesion, including the bone, was first coagulated, the jaw resected later. Radium needles were employed to treat the metastatic glands with X-ray treatment from other portals. A year later a plastic operation was performed, utilizing a flap from the chest.

gastrostomy. This has several advantages, namely, it permits of the building up of the patient's strength, relieves the pain incident to swallowing, and frequently results in a considerable reduction of the swelling and induration in the tongue and pharynx following the rest given to these parts. The tongue can readily be coagulated through its base and then excised, with infrequent primary or secondary hemorrhage; but, to completely obviate these dangers, it is considered safer to do a preliminary ligation of the lingual, or of one, or both, external carotid arteries. Ether anesthesia is employed. The ether should, however, be removed from the room when the patient is fully under its influence and before applying the current, else it might ignite. Should the operation be unusually prolonged and the patient show signs of regaining consciousness, it may be temporarily discontinued as often as required, and ether again

administered. As a rule, however, this operation is of such short duration that the use of ether a second time is not necessary. Scopolamine, gr. 1/100, and morphine, gr. 1/4, may in some instances be used hypodermically one hour before the administration of ether. Less ether will be necessary under such conditions and the immediate post-operative discomfort minimized. After separating the jaws with a mouth gag, a heavy silk suture is passed from side to side through the tip of the tongue, by means of which it is drawn well forward. The coagulation needle is then brought in contact with the anterior surface of the tongue as far back as is necessary and the current turned on either by the operator, by means of a foot control, or by an assistant, on signal. The needle is then moved across the tongue and carefully inserted into it at different points, allowing coagulation to take place as it moves. This having been thoroughly accomplished, the tip of the tongue is elevated by means of the suture and a straight, sharp sewing needle, of proper length, is substituted for the curved knitting needle previously used. The frenum is then coagulated and the needle inserted between the tongue and the floor of the mouth. When coagulation is again completed, curved scissors may be used to cut through the coagulated areas on both surfaces, and the tongue then separated from its attachments. After-treatment consists of simple antiseptic mouth washes and the application, two or three times daily, of Dakin's solution, or one of its modifications, which sterilizes, deodorizes, and tends to keep the slough firm and free from maceration. Care should be taken not to remove the slough prematurely, else secondary hemorrhage may occur. When a preliminary ligation has been performed this, of course, is not so much to be feared. Such a major electrothermic operation should be performed in a well appointed operating room, using the same preparatory technic as in any surgical operation.

In addition to the desiccation or coagulation of the affected tissues, and the sealing

of blood and lymph channels, the heat penetrates beyond the area totally destroyed and devitalizes malignant cells, without permanently impairing the healthy tissue, thus lessening the likelihood of local recur-

clinically and demonstrated histologically. The success obtained in the treatment of malignant disease by the desiccation and coagulation methods is explained by the fact that all the malignant tissue was, when

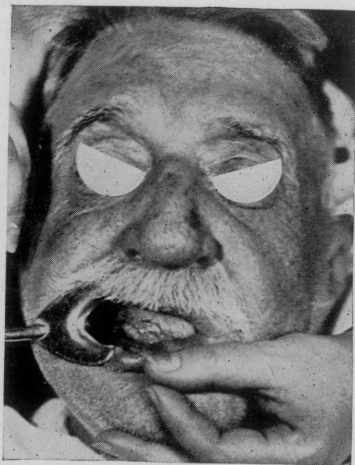


Fig. 10. A. Squamous epithelioma of tongue.



Fig. 10. C. After amputation by the coagulation method. Soft pliable cicatrix.

rence, or metastasis, and conserving the maximum amount of normal tissue. Malignant cells, especially those that are least differentiated, are more vulnerable to heat, and are devitalized at a lower degree of

possible, destroyed with one radical treatment. The practice of intentionally treating a malignant lesion by a series of desiccation or coagulation operations is, however, reprehensible and must be discour-

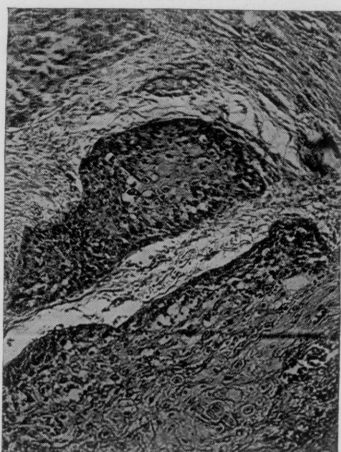


Fig. 10. B. Microscopic appearance of the tumor.

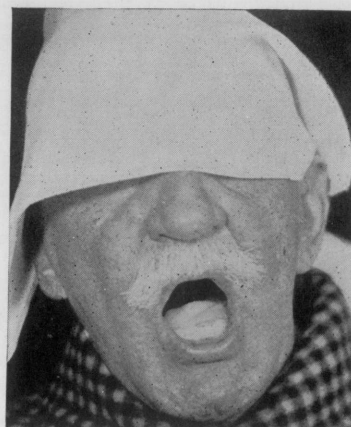


Fig. 10. D. Showing artificial tongue made of moist cotton, materially improving speech.

heat than are normal cells. This thermic sensitiveness to the action of the high frequency current has often been observed

aged. It is quite as irrational to do this as to expect success by surgically excising a cancerous growth in a series of operations.

HISTOPATHOLOGIC STUDIES

In the vast majority of instances, histologic studies of neoplasms are limited to diagnosis. Since the advent of radium and X-rays, not a little attention has been given

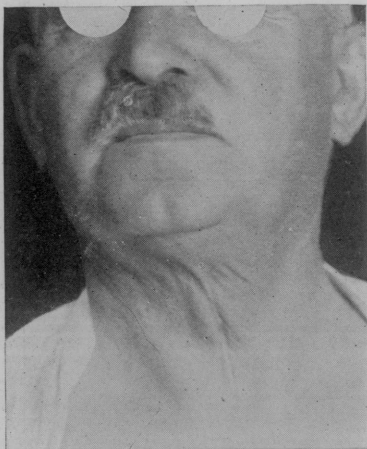


Fig. 11. We no longer attempt to treat malignant disease of the larynx through the mouth by any method. A tracheotomy is first performed, later a laryngotomy (longitudinal slit operation). The lesion is exposed and palpated, and if localized may be desiccated. Small radium needles may be used as a supplementary measure. The above illustrates a case of carcinoma of the larynx treated this way with no recurrence in over three years. In more advanced cases a laryngectomy may be indicated, followed by radium, X-rays, or both.

to the histologic changes in the tissue following the use of these agents, namely, the hydropic and fatty metamorphosis of the cytoplasm, the pyknotic nuclei, the round-cell infiltration and the vascular and fibroblastic changes. As far as we know, no studies have been made of the histologic changes in tissues following the use of the desiccation method, first described by one of us (Dr. W. L. Clark), and that of coagulation, originated by Doyen. During our usual routine of tissue examination for diagnostic purposes, the appearance of the cells submitted to desiccation and coagulation were observed to be entirely unlike those treated with radium and X-rays. This led us to further investigation.

Clinically summarized, the aim of the electrothermic methods is to destroy malignant cells, to seal blood vessels, and obtain

a healing wound with the least amount of cicatrization.

In order to correlate the histologic findings with the clinical results obtained, microscopic examination of tissues submitted to desiccation and coagulation treatment



Fig. 12. Illustrating a type of carcinoma of the breast in which the coagulation method is indicated in combination with radium, X-rays, or both.

were undertaken. The material used consisted chiefly of epitheliomata (basal and squamous cell type), and normal tissues of laboratory animals. The investigation entailed the study of the effect of the current on the cells and blood vessels in the immediate and remote areas of the fields of operation. The histologic pictures obtained were so well defined and uniform as to stamp them with certain characteristics. The cells submitted to desiccation treatment were shrunken and shrivelled, and their nuclei condensed and elongated, with a suggestion of cell outline, the whole assuming a mummified appearance (mummification necrosis). The blood vessels were thrombosed and there were no evidences of hemorrhage. In the case of coagulation, the cell outline was entirely lost, the affected tissue elements fused into a structureless homogeneous mass presenting an appearance not unlike that of hyalinization.

Since the tissues examined were those

obtained at the operating table, no opportunity was afforded to observe the cell reaction likely to occur in the zone adjacent to the area treated. Guinea pigs and rabbits were used for this purpose. Small areas of



Fig. 13. Squamous carcinoma of the clitoris and labia. The desiccation method is indicated to treat lesions of this type, supplemented by deep X-ray therapy to the lymphatic drainage areas.

skin, subcutaneous tissue, and muscle were submitted to desiccation or coagulation treatment and the animals returned to their

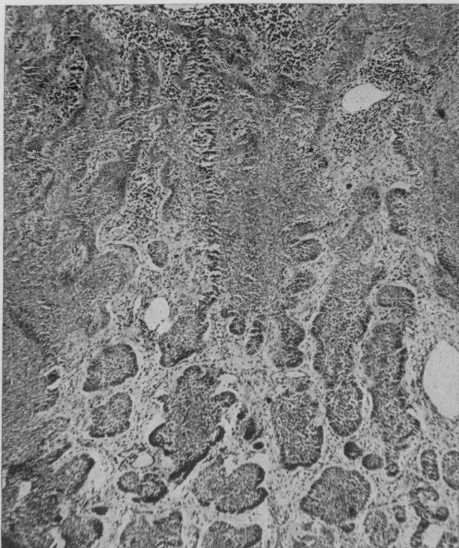


Fig. 14. Section of basal cell epithelioma removed before the application of the desiccation current, showing bulky masses of infiltrating basal cells.

cages. Several days later sections were removed for study. They revealed practically the same tissue changes already noted, but in addition there was round-cell infiltration in the outlying zones, and in certain

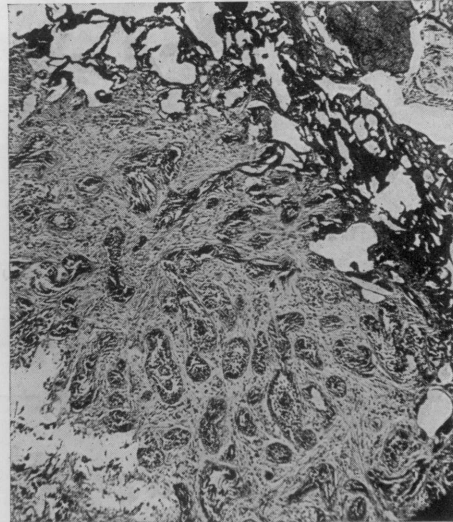


Fig. 15. Same growth as Fig. 14, showing the effect of the desiccation treatment. The cellular masses are definitely shrunken, the individual cells shrivelled, and the nuclei condensed and elongated.

areas this infiltration was localized around the blood vessels.

How may one interpret these histological findings in terms of clinical values? In other words, what are their practical applications?

While it is outside the province of this paper to enter into a discussion of general pathology, it is deemed essential to call attention to a few fundamental pathologic principles in order better to correlate these histopathologic and clinical aspects of the electrothermic methods.

In general, degeneration and necrosis are caused by irritants. An irritant is any agent, or factor, capable of causing a biochemical upset, and is responsible for the histologic changes in the tissues. A degenerative process once initiated, and persisted in, leads to cell necrosis. The necrotic material eventually disappears, and the destroyed cells are replaced by connective tissue. The amount and quality of this connective tissue is in proportion to the amount

and nature of the degenerative and necrotic material which it replaces. Irritants resem-

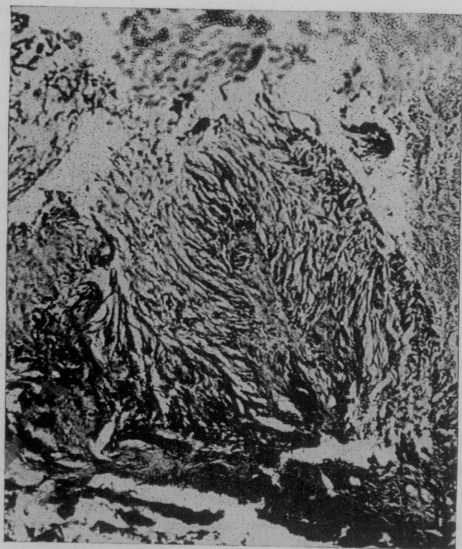


Fig. 16. Basal cell epithelioma, showing the characteristic appearance of the affected tumor elements. The cells appear as long-drawn-out slender threads, the whole presenting a mummified appearance. (Mummification necrosis.)

ble each other in that they are all capable of inducing degeneration, necrosis, and cell infiltration. They differ from each other in the form of degeneration and necrosis,

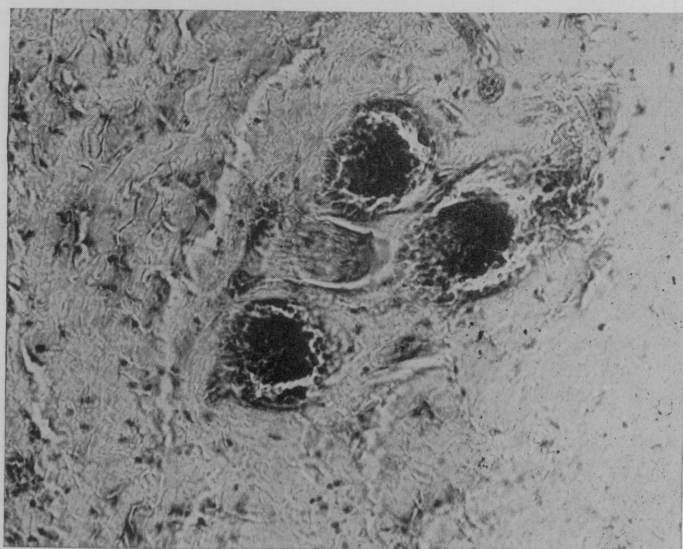


Fig. 17. Squamous cell epithelioma treated by the coagulation method, showing the microscopic appearance of an extensive area resembling hyalinization, and several sharply defined thrombosed vessels. The tumor cells seem to have fused into a structureless homogeneous mass.

and in the type of cell reaction. Whether the degenerative process shall be fatty, hyaline, or amyloid, or the infiltrating cell be a polymorphonuclear, lymphocyte, endothelial, or eosinophile, etc., or the fibroblastic infiltration be diffuse or localized, is determined largely by the type of irritant and its mode of action. Hence, the multiplicity of the various histopathologic phenomena. These, together with the associated secondary changes, give the histologic picture its specific character.

Viewed in the light of general pathology, typhoid, tubercular, luetic, and diphtheretic lesions present the same basic tissue changes, namely, necrosis and cell reaction, the difference being in the types of degeneration, type of necrosis, and character of cell reaction. Their constancy, distribution and particular localization endow these lesions with specific characteristics.

The secondary and associated changes of all lesions are regeneration and fibrosis. Whether the fibrous connective tissue shall be abundant and dense, or less abundant and soft, depends upon the amount and nature of the associated degenerative necrotic materials, which, in turn, is determined by the particular type of irritant. For example, compare the cheesy necrosis of a tubercle, the necrotic material of a gumma, and the pseudo-membrane of diphtheria with their respective associated fibrosis.

The relationship between the type of irritant and the tissue changes induced is so intimate and constant that, given a particular histologic picture, the causative irritant may in most instances be evident. The lesions already mentioned are good examples. Briefly stated, indicate the type of irritant, and the type of lesion can be described. Conversely, give the histology of the lesion, and the nature of the irritant may be determined.

These are the fundamental principles of pathology upon which the histologic studies were based, and it is in this sense that tissues treated by electrothermic methods present histologic pictures which are of such uniformity and constancy as to endow them with specific histological characteristics, namely, the shrunken and elongated appearance of the cells and their nuclei, and the round-cell infiltration in the case of desiccation; and the complete loss of cell outline and hyalinized appearance of the tissue, and thrombosis of blood vessels, in the case of coagulation.

The electrothermic methods are dependent for their results upon the resistance of the tissues to the current, which manifests itself in the formation of heat.

In the case of desiccation, the current being of comparatively low amperage, only a moderate degree of heat is produced, of sufficient intensity, however, to cause complete evaporation of the water content of

the cells, hence their mummified appearance. Since the mode of cell death is associated with very little degenerative change and scant disintegrated material, there is but a small amount of fibrous tissue as an end-result, hence the good cosmetic results and, incidentally, the neighboring healthy tissues are spared the devitalization resulting from the formation of abundant contractile fibrous tissue. The coagulation method, requiring a higher amperage, induces a more intense heat, so that it not only dehydrates the tissues but causes coagulation of the cell protoplasm. This greater degree of destruction results, as we have learned to expect, in a proportionately greater amount of fibrous tissue formation.

Thus, in conclusion, not only are the aims attained, as stated at the outset of this paper, but the electrothermic methods are placed upon an histologic basis and correlated with clinical results.

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