afterwards play on the beach in the bright sunlight till dinner comes along, and an abnormal amount of food is consumed with eager voracity. There follows a period of rest while the food is being digested. The technique for those who cannot walk is much the same, except that their bodies are sponged with warm water instead of having their feet placed in the trough. They, too, enjoy a sun bath after the initial period of rest.

Effect of this Treatment on Patients

Again I would emphasize the need to select patients suitable for the treatment outlined above. Almost all will sooner or later benefit by it, but in many cases we may have to wait a considerable time before it can be applied with advantage. To get the best results I insist upon short immersion in cold sea water rather than long immersion in warm sea water. For English children certainly the cold of the fresh English seas is more suitable than the warm but enervating Mediterranean, and, indeed, I have found the same to be true for children who come from the Tropics. In all of them there is greater metabolic activity, repair is hastened, muscular tone is improved, recalcification of lesions is stimulated, tuberculous glands are more rapidly absorbed, and on sinuses, not kept discharging by dead sequestra, there is an initial marked increase of discharge followed by rapid healing with supple non-keloidal scars. The evolution of tuberculous abscesses is often checked. In short, healing is hastened. The psychological effect is marked: happiness, vivacity, joy of life, is apparent.

Russel also advocated the drinking of large quantities of sea water, but as to the value of this procedure I hesitate, at the moment, to express an opinion.

RADIATION THERAPY OF TONGUE CARCINOMA *

BY

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The tongue is one of the commonest sites in males in which carcinoma occurs, representing*8 per cent. of cases according to Souttar.¹ It appears to be much commoner in males in Great Britain, but it is interesting to note that in the Philippine Islands Fernandez² reports that of twenty-one patients treated fourteen were females. It is a site where extensive loss of tissue produces a most distressing mutilation, and therefore one where it is of paramount importance to conserve as much of the normal tissue as may be possible. It is in this site, as in intra-oral carcinoma generally, that it is possible to speak as does Birkett³ of a revolution in treatment having been brought about by radiotherapy.

Radiotherapy, like ablation surgery, is a purely local method of removal of malignant tissue. We have very little knowledge of how this removal is brought about, but it depends on a differential destructive action which is the greater the more undifferentiated the tissue and the more frequent the mitosis.⁴ It would thus appear that the future control of malignant disease by radiation depends in part on the discovery of means of accentuating this differential action and in part on the earlier commencement of treatment. But so far as the carcinoma in the tongue remains a local disease, and, in particular, before it has extended from its original site to the regional glands, it is eminently curable if sufficiently

radiated. This radiation can be brought about without any ultimate loss of tissue other than that occasioned by the removal of so much, and no more, of the tongue as is carcinomatous.

The Normal Tongue

From the physiological point of view the tongue is concerned with speech, and also partly with the sense of taste. It is uncommon for taste to be seriously affected, and the mobility of the tongue and the degree to which it remains intact influence the extent to which normal speech remains possible. Radiation, however, markedly affects among normal tissues the salivary glands, and hence it is that dryness of the mouth is usual in patients treated by radiation for carcinoma of the tongue. But recovery in some degree of the secretory glands and habituation in part lead, as time goes on, to an amelioration in this symptom.

Anatomically, the tongue consists of two longitudinal muscular masses. Joined medially by a fibrous layer, they are covered on their free aspect by squamous epithelium. The anterior two-thirds of the tongue lies in the mouth, and the posterior third forms the anterior wall of the pharynx. The blood supply is derived from the lingual arteries. The lymphatic drainage of the anterior part of the tongue is to the submental glands and the anterior cervical glands. From the lateral part drainage is to the submaxillary group and to the upper cervical glands. At the root of the tongue median vessels pass through the muscles to end in the submaxillary groups.

The Histological Picture

Histologically, the growth from the mucous membrane is a squamous-celled carcinoma showing differentiation to a greater or lesser degree. In a recent series of seventeen biopsies of my cases, five were reported as squamous-celled carcinoma without amplification. Of the remaining twelve, one showed moderate differentiation, whilst in eleven the growth was well differentiated. None of these, however, had originated in the posterior third of the tongue, where growths of very anaplastic type may occur.

In general, the less differentiated the growth the greater the response to radiation. But this apparent advantage is more than offset by the increased likelihood of early dissemination. When, however, it is a matter of judging the course an individual case is likely to follow, the histological picture is not always a sure guide to the response that can be expected. Indeed, Martin⁵ thinks grading is of little value except as regards the probability of early metastases. The view formerly held by many that biopsy increased the probability of metastasis does not obtain to the same extent to-day. The absolute amount of tissue excised is not very large, and the trauma consequently slight, but to be on the safe side I prefer to use a small snare with a diathermic current of very high periodicity. Little distress is caused the patient, and the tissues are instantly sealed. With the very high frequency the depth of tissue coagulated is small, and hence small portions removed at the growing edge enable a sufficiently large section to be made to permit study of the growth.

It is preferable to put the mouth in good condition before implantation of radioactive sources, and, in particular, to remove septic stumps or dead teeth and to treat those teeth that are carious. But the advantages are not all on the side of unduly extensive teeth extraction, nor can it be said that no risk exists of the implantation of cancer cells in a socket whence recently a tooth has been extracted. Some patients, too, may fail to see the connexion between removal of highly valued teeth and their tongue ulcer, and so refuse extraction. In such cases I have not observed any untoward result from

* Read in opening a discussion in the Section of Radiology and Therapeutics at the Annual Meeting of the British Medical Association, Melbourne, 1935.

implantation without interference with the teeth. It is well in cases of this kind, however, to pack the tongue away from the jaw with gauze. Even when the mobility of the organ is destroyed the displacement of the source of radiation a few millimetres from the jaw greatly diminishes the radiation this may receive. ♦

Methods of Irradiating Primary Growths

There are several methods possible of irradiating the primary growth in the tongue. It may be done either by interstitial, surface, or distance methods of employing radium or radon, or by Roentgen rays from a greater or lesser distance.

Interstitial methods first employed by Dominici⁴ were those in which a metal container enclosing the radioactive material was embedded in the tissues. The radiation employed nowadays is the gamma radiation from radium C (C', C'') obtained from radon gas. This radon gas in the case of "seeds" is filled into them from an external producer of the gas—namely, a radium salt in solution. In the case of "needles" the radium is contained in the hermetically sealed needle, and there produces its radon gas, which in turn changes to radium C, from which the gamma radiation arises.

Now by reason of the fact that radium changes into radon very slowly, while radon changes much more quickly (the ratio of the times is approximately 150,000 to 1), it follows that a radium-containing needle emits a constant radiation over periods of time very considerable as compared with those employed in treatment, while from a radon-containing seed the radiation diminishes to one-half of its initial value after approximately four days. Thus, from the practical point of view, if seeds are used the radiation intensity, relatively strong at first, diminishes to a negligible fraction of its original strength at the end of a week. With radium needles a uniform intensity of radiation is obtained throughout the period of treatment. In practice, however, if the total dose be correct, this variation of intensity during treatment is of no disadvantage. Seeds, on the other hand, are of negligible intrinsic value, and can be made very much smaller than needles. Furthermore, it is possible to utilize a greater proportion of the length of the seed than is the case with a needle, the active length of which (or that part from which the radiation is emitted) is much less than the total length, more especially in small needles such as are used for the tongue. The preparation of seeds, however, requires a radon-production plant, and so, except in larger centres, is not convenient.

Interstitial methods are the methods chiefly employed, but for a small accessible lesion use may be made of a surface applicator, preferably in a ring or hollow square form. Distance radium, or beam, or "bomb," or—to employ the French term, *télécuriethérapie*—does not lend itself conveniently to treatment of a primary lesion situated in the tongue. The needles I have used have been of low linear intensity—namely, 0.66 mg./cm. In making an interstitial implantation it is first necessary to judge the extent of the tumour. This is not always easy, but a boundary well outside any induration or deformity should be chosen.

Technique Using Radium Needles

It is now necessary to plan the radiation so that the whole volume chosen as definitely enclosing the tumour shall be irradiated as uniformly as possible. An approximation, but an approximation only, to the necessary dosage is given by allowing 1 mg. of radium element per c.cm. of such space. But in small tumours this will be much too small and in large tumours somewhat more than is necessary. The needles are placed so as to irradiate the margins of the growth, and also beyond them to

include as much healthy tissue as will ensure that the radiation at the growing margin and a safe distance beyond it is reasonably uniform. Time—about ten days; but this varies with the nature of the tumour.

Various methods of fixing the needles in the tissues have been described, and it is claimed as an advantage of radium needles, and also for needles containing seeds, that they permit a more accurate fixation and distribution than is possible with seeds alone. Pridie⁷ has described a method of fixing a needle at both ends, and Muir⁸ has worked out a technique for fixing seeds. Souttar¹ and Birkett³ recommend the fixation of the eye of the needle by a catgut stitch in the mucous membrane, but in my experience, if the thread to which the needle is attached is led to the same side as that to which the point of the needle is directed, the needle will not become displaced. If the threads are disposed in this manner they may be grouped—for example, one group for each side. The threads of a group can either be fixed with a single stitch to the tongue or else taken out directly through a fine rubber tube and strapped to the cheek. If a needle does come out it can usually be reinserted in position without much difficulty, except in those cases in which the growth is extremely friable.

It is important in inserting a needle to see that the eye goes just beneath the mucous membrane where this is intact. The intensity of radiation at the end of a needle is relatively very low, and for this reason it is essential that in planning the distribution this be arranged so that the ends and points are in normal tissue, except where the point does not penetrate so far as to the opposite side of the growth. In this case a second row from that side is necessary. In large tumours the central portion should have its needles further apart than is suggested above. Instead, the distribution of the needles may be that of a broad ring, the effect of which will be to give an approximately uniform radiation throughout the tumour. In any case of doubt, the radiation being uniformly distributed, it is better to over-dose than to under-dose, for while a local recurrence can be re-treated, this is not so simply nor so safely done as is the removal of a small central ulcer due to radium over-dosage. Such an ulcer can be easily treated after its margins are definitely established and the boundary between the damaged and healthy tissues easily seen. Removal of the ulcer crater by diathermy to a depth of a few millimetres is rapidly followed by the growth of epithelium.

I have already referred to the advisability of packing the tongue away from the jaw in cases in which much radium is disposed on the lateral margin of the tongue. The use of lead for such a purpose is sometimes advised, but in any practicable thickness it is of very little use—for example, if 5 mm. of lead is used the reduction of the hard gamma rays is less than 25 per cent.⁹ In addition, the lead, under the influence of the transmitted gamma radiation, emits a very caustic radiation at the surface in contact with the jaw. It is far better when protection is sought to rely on distance, and to use in the case of the tongue, for example, a hollow vulcanite box fixed to the teeth or jaw. The increased distance from the radioactive source thus obtained will diminish sufficiently the intensity of the radiation, while the elements of light atomic weight forming the black vulcanite will not themselves be a source of harmful radiation.

Radiation by Roentgen Rays

Another method of irradiating the tongue is by Roentgen rays. Up to the present their application has been technically difficult, and radiation by the ordinary Roentgen-ray tube would hardly be attempted save in cases where radium treatment was impracticable. Dufour and Cottenot¹⁰ describe a case where some temporary

improvement resulted, and I have personally treated two patients with large fixed tongues and large bilateral adenopathy in whom there was a marked palliation of symptoms, though this was merely temporary.

In recent years Chaoul of Berlin,¹¹ struck by the results obtained with radium in growths of small extent, and from a consideration of the physical principles involved, has employed a Roentgen-ray tube operated at a very short distance from the part treated. In general the use of radium at very short distances from a tumour has been regarded as disadvantageous. This disadvantage arises principally from the difficulty of securing homogeneous radiation. In using Roentgen rays at extremely short distances Chaoul has reproduced one feature of gamma radiation—namely, that the total amount of radiation absorbed in the tissues is much less than in ordinary Roentgen radiation. Later Chaoul¹² reported 103 cases, of which ninety-three were symptom-free for one year or more. As only half these cases were of skin carcinomata, and cases of cancer of the tongue were included, the method appeared to be one of promise. The technique employed¹³ would seem to be the giving of a daily dose of about 400 r for about twenty days to a very small field, at most two inches square. The conditions under which this dose is administered are 150 r/min., kV 60, filtration 0.5 Cu, half-wave rectification. The method is well worthy of investigation, but so far as the tongue is concerned the question is one of access. At present apparatus for this method, consisting of specially adapted applicators attached to shock-proof Roentgen tubes with unipolar grounding, is made only in one European country, but it should be inexpensive and simple to manufacture, and if the demand arises should be capable of production by any manufacturer. It is to be noted that the dosage given by this method follows Coutard's system, in so far as it employs a multiple daily split dose. It differs from his in the use of a relatively high intensity (r/min.).

The method in principle has one advantage over interstitial or radium puncture radiation. The tumour is not injured as it is by the insertion of radium needles. This insertion must introduce a definite risk of increased metastases. For example, the use of ten needles each an inch long means ten inches of punctured wound in the tumour, or a raw surface of an area perhaps of nearly one square centimetre. The total dosage is quite high, and compares with that given by interstitial radium, stated by Martin and Quimby (quoted by Quick¹⁴) to be 7 to 10 E.D. for epidermoid cancer and 3 to 5 E.D. for anaplastic types.

Radiation in Gland Areas

The question of treatment where the glands are involved remains one of difficulty. There is a marked decrease in the survival rate in such cases. Several methods are available: ablation, radium implantation, Roentgen radiation, and radiation from a distance, either short with multiple sources on an appliance, or long as with beam therapy (telecurietherapy). The first, if thorough, is as good a method as any. It suffers, however, from a fairly heavy operative mortality rate. Radium implantation can be done either through the intact skin or after operative exposure. The former appears somewhat inexact, even if not hazardous, but it is recommended by Cade¹⁵ if the glands cannot be palpated. Often exposure and consequent implantation of radioactive sources permit a more exact distribution, and therefore a more uniform intensity, but by reason of space considerations and the shape of the gland-bearing areas uniform radiation by means of implanted sources is not easily accomplished.

Radiation from sources disposed on appliances made in the form of a collar of Columbia wax, or of nidrose, or

of stent¹⁶ allows more uniform intensity of radiation—as does radiating by beam from a single source at a greater distance—than it is possible to use in the case of appliances worn by the patient. In both these cases the skin presents the limiting factor in the dosage possible. Finally, in Roentgen radiation of the gland-bearing areas, the limitation imposed by the skin toleration, even with prolonged fractional radiation of low intensity, prevents in many cases dosage being given in sufficient amount to eradicate the malignant tissue.

Results of Radiation Treatment

The results of radiation treatment in cases of carcinoma of the tongue are from some aspects very satisfactory and from others much less so. In the first place, in all cases severe mutilation is avoided and great palliation, at least of distressing symptoms, is obtained. We have no figures as yet in Egypt either of the incidence of lingual carcinoma or of survival rates after operation. With radium implantation of the primary growth, and x-irradiation in most cases of the gland areas I have treated thirty-two cases since 1929. Economic reasons bring patients to us very late and prevent their regular attendance, but an attempt has been made in every case to trace the patient through the civil administrative authorities, and this has been successful in twenty-one instances. Of these twenty-one patients eighteen are known to be dead; three are living and apparently free of their disease.

According to Cade,¹⁵ healing of the primary lesion is obtained in the majority of cases (74 per cent.). As against this, in the cases where the disease has ceased to be local, this author in 1930 claimed 11 per cent. of five-year, 26 per cent. of three-year, and 48 per cent. of two-year periods in which the patients remained symptom-free. Pfahler and Vastine¹⁷ claim an absolute three-year period of freedom from symptoms in 29 per cent. Rose and Phillips¹⁸ claim 33 per cent. remaining symptom-free for two years. Raven¹⁹ gives 26.6 per cent. surviving three years after treatment with radium and surgery, as compared with 6.8 per cent. with radium only and 19.7 per cent. with surgery only. He states that eight patients treated with x rays only were all dead, though obviously such patients would not be of a type suitable for radium or surgery. On the other hand, H. E. Martin²⁰ reports a patient well after twelve years. Berven,²¹ for the years 1922–6, reports 32 per cent. of cases of lingual carcinoma symptom-free after five years, and similar figures are published by the Fondation Curie.²² These figures contrast with those quoted by Gask,²³ who is of the opinion that the best survival rate to be expected from surgery alone is 20 to 25 per cent.

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