more markedly raised about the time of incidence of the toxæmia and in the post-partum period. These results, though few in number, serve to emphasize that the occurrence of a raised blood sugar curve at any stage of pregnancy is of importance. Dietetic treatment by meals with the carbohydrate content evenly spaced can then be instituted to avoid miscarriage or premature birth.

Conclusion

The scope of this paper has been limited to the effect of anaemia as an aetiological factor in the development of toxæmia. The haemoglobin curve appeared to follow the duration of pregnancy: in the untreated cases the haemoglobin dropped persistently, whereas in the iron-treated group it rose. There was no seasonal variation in the haemoglobin curve.

Although some workers have failed to show that there is any connexion between anaemia and toxæmia without pre-existing renal disease, in our small series of cases the incidence of toxæmic signs or symptoms is much lower in our iron-treated series than in the controls. In other

words, when the haemoglobin value is kept up in the region of 90 per cent. the incidence of toxæmia is lowered.

We should like to take this opportunity of thanking Professor Amy Fleming for permission to investigate these patients; Professor Robert A. Webb in whose department the work was carried out; the Medical Research Council for a grant allotted to us for this investigation; Miss M. B. Harford, B.Sc., A.I.C., for her technical assistance with the biochemical investigations; and to Mr. Luck for producing the charts.

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MILD RADIUM THERAPY*

BY

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My reasons for presenting a paper on treatment by radium emanation, called indifferently mild radium therapy, radon therapy, emanotherapy, may be briefly stated. Here we have a therapeutic agent which has been used empirically for ages, scientifically for thirty or forty years, and yet is very little known in this country, although now employed abroad in many ways, such as in the form of compresses, sprays, subcutaneous injections, baths, inhalation, drinking-water, etc. Once looked upon by the medical profession with distrust, this form of treatment has now a definite place in physical therapy, and as Bickel of the Charité, Berlin, said:

"Twenty years' experience of radium emanation therapy has now established the method as a recognized form of medical treatment, and it is likely to be used more extensively in the future."

It is a therapeutic agent now modernized and scientifically used. It was blessed by no less an authority than d'Arsonval in a communication to the Académie des Sciences (June 13th, 1932), after an experience with the gas of over five years. It is being used in no fewer than twenty hospitals in Paris, and also extensively in many countries besides France, notably, Germany, Italy, Czechoslovakia, Spain, Portugal, and the U.S.A., and it is to bring before the medical profession of England this form of therapy, and to have it used in our hospitals as it is being used on the Continent and to induce our spas to add it to their armamentarium, that this paper is presented.

Another reason is to clear the widespread error that radon was dangerous. It is still confused in the minds of many people with radium. Radium and radium emanation are not the same; on the contrary, they are distinctly different, but still too many people, even in the profession, impute to the beneficent qualities of emanation

the dangerous properties of radium itself. Radium emanation cannot possibly be dangerous; it is essentially innocuous, and even its opponents, who can hardly be considered authorities on the subject, sometimes admit it may be beneficial.

Alleged Dangers of Radium Emanation

At the outset perhaps it would be as well to recount the origin of the legend of the dangers of radium emanation which gave rise to the well-nigh universal impression that radium gas is dangerous. It is not dangerous. It is from radium and radium salts the danger comes, as the following cases, which are so often quoted, go to prove.

During the years 1917 to 1924 an accumulative total of 800 girls were employed in a factory in New Jersey, U.S.A., painting the dials of watches and clocks with luminous paint. This paint contained phosphorescent zinc sulphide, activated by means of small amounts of radium and its congener, mesothorium. Several of the girls employed developed a very resistant infection of the jaw, with buccal lesions and marked anaemia, and later they died of carcinoma.

It is important to note that it was only the girls who had worked steadily in this painting for from one to two or more years who showed effects of radium poisoning.¹ In these factories the radium paint was mixed with acacia, which was thinned out with distilled water, and given to each girl in a porcelain crucible. It was the habit of most of these girls to point the tip of the camel-hair brush used in painting with their lips, so that a more accurate work could be performed. The material for the painting was sticky and adhered to gums and teeth, and was difficult to expectorate; one girl stated it was gritty, and she always swallowed it, as doubtless did the rest of the girls. The report showed that in six months anything from 360 micrograms to over 5 milligrams of radioactive substance might have been swallowed.

The other case so often quoted, which must be mentioned only in order that the danger of radium emanation may be refuted, is that of a gentleman of Pittsburg, who drank thrice daily, for a considerable period, a solution of soluble radium and mesothorium in an endeavour to rejuvenate himself and improve his golf. He developed carcinoma and died.

So these cases, arising as they do from radium itself or radium salts, have nothing whatsoever to do with mild radium therapy.

* Read in opening a discussion in the Section of Physical Medicine at the Annual Meeting of the British Medical Association, Oxford, 1935.

The ingestion of radium salts, as I have related, as done by these girls, or as the gentleman from Pittsburg did, is totally distinct and apart from the administration of radium emanation as it is given in mild radium therapy. Radium salts ingested will undoubtedly leave active deposits of radium in the bones, which will remain there active for 1,750 years; but no matter what the quantity of radium emanation be taken it is all gone in 3.85 days.

Furthermore, it has been stated also that radium emanation killed the miners in the radium mines at Ste Joachimstaal; but as I pointed out in 1934² it was not until the pneumatic drills were used that there was any dangerous trouble of the lungs, and it was by the inhalation of the dust containing radioactive substances that the trouble came. Again radium solid particles and not radium emanation.

Rise of Emanotherapy

At several congresses abroad which have taken place in the last few years the subject of emanotherapy has been given a definite place; at Zurich, Liège, Paris, Copenhagen, and Stockholm it was freely discussed, and I felt that this Annual Meeting of the British Medical Association should not take place with the subject of emanotherapy unmentioned, and radium emanation, Cinderella-like, left out of the party. For I venture to prophesy that, even as Cinderella, it will one day be appreciated and take an important place in the world.

When I said that radium therapy had been used empirically hundreds of years ago I referred to what was termed the Holy Earth, which can be seen to-day in the leather bags of Bohemia, or, as it is now called, Czechoslovakia. These I have seen in the neighbourhood of Ste Joachimstaal mines, whence came the ore from which Madame Curie first extracted and identified radium. These bags were the forerunners of the radium pads of to-day. In the eighteenth century the attention of scientists was directed to Bad Gastein and other German springs. Baron Liebig described their healing qualities a hundred years ago, and later Burckhardt Elbe came to the conclusion that the waters contained a gas which in due time would be identified as the active substance, and in the year 1903 the gas was recognized as radium emanation. Other examples of its therapeutic value recur through history. In France it was said of the spas: "The baths preserve the health and give the 'joy of life.'"

And so in different countries, notably Germany perhaps, the same idea keeps recurring. The springs have such names as "The Spring of Eternal Youth," "The Spring of Rejuvenation and Regeneration," "The Spa for the Ancients," "The Fountain of Perpetual Youth." The legend of the revitalizing power of the waters has existed throughout the ages in all those countries where healing springs have been found, and has persisted from time immemorial even up to the present day.

Mild radium therapy has the endorsement of some of the greatest men in the world. D'Arsonval I have already mentioned; Dausset of the Hôtel-Dieu in Paris only two months ago told me that he had done over 20,000 cases without a single mishap.

Among others who have testified to the therapeutic value of this form of treatment are: Professor Eiselsberg, one of the world's surgeons, holder of the Lister medal; his successor, Professor Denk; Professor Felham, doctor to the former Empress of Austria; Professor Ortner, doctor to the late Emperor Franz Joseph; Professor Lorenz, head of the Lorenz Orthopaedic Clinic; Professor Singer, the internationally known authority on rheumatism; Professor Novak, the gynaecologist; Professor

Wenckebach, the heart specialist; and Professor Newmann, the throat specialist, who lectured a few years ago before the Royal Society of Medicine; in Berlin, Professor Sauerbruch, who gave the name to the famous chest operation; Professor von Lichtenberg, the eminent neurologist; Professor Cramer, one of Berlin's leading physicians; Professor Goldstein, the famous nerve specialist; and in Munich, the internationally known gynaecologist, Professor Döderlein.

And the subject of emanotherapy has not been altogether unknown by authorities in this country. Mutch in the *Lancet* (1911), Luff in his book on Gout, Bannatyne of Bath in Hutchison's *Index of Treatment*, Dawson Turner in *Radium and its Physics and Therapeutics*, and Davy Luke in *Spas and British Health Resorts*—all speak favourably of this form of treatment.

It is needless to enumerate the spas abroad where this treatment is used. You are all familiar with them, and they are each proud of the radioactivity of their waters and of the results obtained therefrom; but in our own country, perhaps, Bath stands almost alone in its radioactivity. A great deal of the value of spa treatment is due to radioactivity, and on the Continent especially the higher this property the more health-giving the spring is reputed to be, and in a great measure the spa treatment is mild radium treatment. It is far from my intention to decry or to undervalue either the treatment or its value, but if a criticism is to be made it would be that it appears to fall short of perfection in the matter of accuracy of dosage, and this brings me to describe the apparatus by which to-day accuracy is ensured.

It was on the suggestion of Professor d'Arsonval and under his direction that one of his pupils, Dr. Vaugeois, invented generators of emanation or radon emanators. These are generators of a pure emanation, without danger, and of constant and known output. They are easily transportable, and allow of the emission of radon gas in a definite quantity in a given time.

Methods of Administration

Reference to Fig. 1 will show the principle of an emanator. A is a metal tube in which is inserted, in a small container (B) a given quantity of radium salt. The quantity of radium salt is that which is sufficient to give off a definite quantity of radium emanation in a given time. For example, this tube will produce 1,000 millimicrocuries of gas in twenty-four hours. Perhaps it

FIG. 1.—Radon emanator. Scale 1/4.

would be as well here to explain how the gas is measured, and the following table will show.

- 1 curie = that quantity of emanation in equilibrium with 1 gram of radium element.
- 1 millicurie = 1/1,000 curie.
- 1 microcurie = 1/1,000 millicurie.
- 1 millimicrocurie = 1/1,000 microcurie.

If we wish to administer the emanation by means of drinking-water (Fig. 2) we pour some water into a bottle, put the cork into the bottle, and then put the emanator on to the cork, turn the tap of the cork and the tap of the emanator on so that the emanation, having an atomic weight of 222, falls down, by reason of its weight, and at the end of twenty-four hours the 1,000 millimicrocuries will have been absorbed by the water, which is then ready to drink.

Another method of administering it is by subcutaneous injections, and it is to this method that Professor Dausset refers, and is one almost exclusively used by him. Here we have the same emanator, and it comes in a box with

the hour and date entered on it, which can be adjusted each time it is used. A needle is fastened to one end and a cylinder of oxygen to the other. The rate of flow is regulated so as to produce 35 to 50 cubic centimetres per minute, and it is also filtered by means of cotton-wool. The gas is allowed to flow for three minutes, by which time the oxygen has emptied the emanation and carried it into the subcutaneous tissues. The treatment is painless. There are several other forms of syringe for the subcutaneous or submucous injections into which we need not enter here.

Another method of administration is by rectal insufflation, and indeed this is the method of choice for certain

FIG. 2.—Radon emanator for drinking-water. Scale 1/4.

FIG. 3.—Radon insufflator. Scale 1/8.

gynaecological affections. In this method a large rubber catheter is used; it is attached to one end of the emanator and the other to the oxygen cylinder or the double-bulb air syringe, and this latter arrangement the patient can manipulate herself.

Another method of emanotherapy is by means of a spray (Fig. 3). The gas as before falls down to the water and the air pumped through the water carrying the emanation to the affected part. This is not only used in gynaecology but also in oto-rhinology.

Nor must the treatment by the application of radium pads be omitted. These I have used since 1912, after reading Dr. Mutch's article in the *Lancet* (1911). Each pad consists of a dry compress of radioactive substance sewn in a bag of waterproof material, which in turn is contained in a loose washable cover. These are applied to the painful area and kept in position by a bandage, and left in position for hours or even days.

In this connexion mention must be made of the thermo-radio pad, described in the *Lancet* (February 22nd, 1930); the benefit obtained was derived from a combination of radium emanation and equable heat. Logically it is impossible to say whether the benefit resulted from the one or the other of these two therapeutic factors or from their simultaneous action. If so, it is only fair to record that this is not the only example of mutual intensification where synergic action has been used in physiotherapy. There are several other instances which will doubtless be called to mind by physiotherapists.

Another outward form of application is radium emanation ointment or pomade. Here we have an activated ointment which is spread on the skin and covered with tinfoil and strapping applied and left on for a varying number of hours. The objection to this is that it is only manufactured abroad and by an expensive apparatus, but doubtless time will overcome this obstacle.

Inhalation is, like the pads, one of the oldest forms of administration. The Romans used to build rooms or tents over the springs where the gas was rising from

the earth, and they were known as emanatoria. The modern emanatorium is usually a room, and the radium gas is pumped into the room, and patients remain in it for an hour or more. This is an example of inaccuracy of dose. The quantity of emanation varies in almost every part of the room, the tendency, of course, being for the greatest quantity to be on or near the floor, and it will be readily recognized that there are other ways in which the quantity will vary. Many methods have been tried to overcome this, one of which is a mask; but even with this it is difficult to say really how much emanation the patient inhales. By the aid of Major Collison and an engineer a rather elaborate but absolutely accurate machine has been devised, but a description is out of place here.

Indications for Mild Radium Therapy

The class of disease in which radium emanation treatment is indicated and in which it has been used and found beneficial one may summarize for general terms as follows:

1. In "gout and goutiness," to borrow a title so well chosen by Leonard Williams. In rheumatisms, especially those of infectious origin and characterized by pain. In fact radium emanation would appear to exercise a sedative action on most varieties of pain.

2. Mild radium therapy has been successfully used in certain gynaecological conditions, notably pelvic pain and congestion, and salpingitis, and is used extensively in the treatment and cure of sterility.

3. In dermatology such skin affections as psoriasis, mycosis fungoides, eczema, and lichen have benefited from its use.

4. In diseases of the respiratory organs and upper air passages chronic catarrhal conditions and affections of the sinuses have improved with the use of mild radium therapy.

5. Much as I object to the term "rejuvenation," the age-old reputation with which radium emanation is endowed cannot be omitted and would appear to be more or less justified. I think perhaps "revitalizing" is a better and less misleading term than rejuvenation, and certainly it is this quality which makes the treatment useful in convalescence, notably from septic troubles. It is eminently suitable in the complaints of middle and old age, premature ageing more especially, in recuperation, in cases of exhaustion or weakness following operation, long illness, or overwork.

Rationale of Radon Gas Therapy

To bring the uses of emanotherapy up to date its value in the treatment of mental disorders is forcibly brought to the notice of the medical profession by the recent report of the medical superintendent of the Crichton Royal Institution in respect of the year 1935,⁴ which is as follows:

"It is an interesting coincidence, and a possible and suggestive explanation, that towards the end of 1931 the artesian water supply of the Institution was considerably increased by the boring of another well, providing twice as much water as the former well, and that the water of the new well is two and a half times as radioactive as that of the old well. The radioactivity of the waters of the two wells was carefully examined and estimated by Professor James Muir, D.Sc., of Glasgow, who found that the water from the old bore has 60 units of temporary radioactivity or the average for deep wells, whereas that from the new bore has 150 units.

"Radiotherapy has hitherto not been employed in the treatment of mental diseases, and probably mainly for the reason that mental disorder is not a 'localized' affection, like cancer in its early stage, which can be treated by carefully localized application of radium. Mental diseases, on

the contrary, are affections of the whole body, mind, and personality, and their therapy involves the treatment not only of the brain and nervous system, but also of the whole organism, including, in addition, the individual's social relationships. The characteristic process of the bodily chemistry or metabolism is oxidation, and notably in melancholia and dementia the basal metabolic rate is lowered, with resulting accumulation in the system of unoxidized and other toxic products of metabolism. If the proved curative effects of certain radioactive mineral springs in gout and allied affections of the fibrous tissues, muscles, and joints are attributable in part to their radioactivity, they possibly operate in this respect by stimulating the metabolism and activating the oxidative processes of the body. If this surmise is correct, then there would seem to be a sound reason for the use of radium in the treatment of mental diseases, in some mild and generalized form, as by the drinking of radioactive waters and the taking of radioactive baths; and possibly this may help to explain the improvement in the recovery rate at Crichton Royal during the past four years—that is, since the opening of the new artesian well towards the end of 1931, with its more copious supply of more radioactive water than that of the former well."

The theory of the manner in which radon gas exercises its beneficial effects one may gather from the above report. The French authorities state that emanotherapy brings about the restoration of the vital potentials of the cell and places them again in a state of equilibrium. This effect is produced either by stimulation or by sedation.

Stimulation in the Case of Hypofunction.—Here we have a threefold action: (a) an action that would appear to be almost specific in diseases which are due to a slowing down of metabolism; (b) a detoxicating action, brought about by the elimination of the microbic metabolic toxins which were paralysing the cellular function; (c) an auto-infective action due to phagocytosis.

Sedation.—This is due either to the stimulation of the hypofunction as above or to a sedation or slowing down of the hyperfunction, as a result of which there is: (a) a sedative action on pain by the action of radon on the irritated nerve cell; (b) a regulation of the sympathetic system, by reason of its action upon the basic and primary (cellular) cause of the pathological condition.

In other words, the action of radon is indirect, affecting not so much the involved organ or tissue as the body as a whole. This is brought about by a direct transference of energy from the emanation to the tissues, one result of which is increased oxidation of the cells, thereby favouring osmotic exchanges and elimination of waste products.

Conclusion

These findings suggest, as a possible rationale for emanotherapy, that the emanation, by virtue of its positive and negative charges, may remove the electric charges from the body colloids, and have a stabilizing action resulting in a sedative effect on the tissues.

The rationale of the radon treatment of rheumatism is one of oxidation and detoxication. As Dr. Buckley said, when writing on the treatment of arthritis recently: "The one indisputably sound line of treatment in all cases is to raise the patient's resistance to a point which will enable the infection to be overcome."⁵ And there is no doubt that treatment by mild radium therapy does raise the patient's resistance in a remarkable way.

Of emanotherapy we shall learn more as time goes on, and of its rationale and the way in which it works; and with this knowledge we shall find new channels for its activities. In the meantime, it behoves us to proceed with caution, but also with diligence, in close co-operation with the scientist and our fellow workers, and devote to it, and to the work of others, that same attention which has brought many of the more recent physiotherapeutic measures into practice.

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GASTROGENOUS POLYNEURITIS

BY

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Over many years literature has accumulated relating to cases of widespread peripheral neuritis, unrelated to any obvious causal agent and often fatal. In the last six years I have encountered seven examples of severe polyneuritis, in each of which there was some associated disease of the stomach. It occurs to me that this association may not be a matter of mere coincidence, and that if in all cases of polyneuritis of obscure origin a full gastric investigation were undertaken a causal relationship might be made out between gastric disease and the general involvement of the peripheral nerves.

I have had no opportunity of investigating any case of progressive hypertrophic polyneuritis, such as was described originally by Déjerine and Sottas, in which a familial tendency to the occurrence of the disease is striking. On the other hand, a paper by de Bruyn and Stern¹ gives a very full account of a case which they studied. It relates to a male, whose symptoms began at the age of 49, and who died three years later. The immediate interest of this paper lies in the fact that the patient's sister and two brothers had died previously after an illness characterized by vomiting, diarrhoea, wasting, and pains in the limbs; in the brothers, no free hydrochloric acid was present in the gastric juice. In the case described in the paper hydrochloric acid appeared only after two hours' digestion.

Harris² reports a case of relapsing interstitial hypertrophic polyneuritis, in which the attacks of weakness, loss of sensation, paraesthesiae, and loss of tendon jerks were intermittent, with complete recovery between; death followed six years of illness. There is no note of any gastric investigations. The same author³ in 1935 writes again on chronic progressive (endotoxic) polyneuritis, and describes five cases of the relapsing variety. He suggests that all cases of recurrent or progressive polyneuritis, excluding Déjerine's familial type, whether associated with enlargement of the nerves or not, be grouped together as variations of a disease and be described as chronic progressive endotoxic polyneuritis. This suggestion clearly visualizes the production of some toxin as yet undetermined in the body, and the definition may be taken to exclude obvious causes of polyneuritis, such as poisoning with arsenic and other substances, gross sepsis, and so forth. My interest in the matter arose through the observation of cases already referred to, which I will describe briefly.

Case Reports

CASE 1.—A male of 42, complaining of pains in the legs, loss of power in the legs, hands, and arms, numbness of the feet, and general malaise, had a sensory loss of glove and stocking distribution; loss of knee-jerks and ankle-jerks; tender calf muscles; pronounced wasting of the muscles in the legs, hands, and forearms; and the reaction of degeneration in the peronei and anterior tibial group. The nerves were not obviously thickened. General examination revealed no other abnormality and the Wassermann reaction was negative. The disease progressed rapidly and in three weeks vomiting began