annoyance to those about him. The operation was carried out in two stages, and after a rather prolonged convalescence he eventually made a very good recovery. His gain in self-respect was extraordinary, and it was a remarkable thing to see this patient some months afterwards, nicely dressed, with white spats and a smart tie, and an undoubted concern for female regard. This happy state continued until four years afterwards, when he died of some condition unassociated with his prostatic troubles, but the details of which I have never been able to ascertain.

The after-history of very many cases is similar, and I merely select a few at random, as I know that many of you, from individual experience, will be able to supply many telling examples. The following is a very striking case.

A man of 60, a hard-working, conscientious artisan, whose symptoms had extended over some years, had evidently suffered so much from renal disability that his working capacity was seriously impaired. The operation had to be carried out in two stages, and his convalescence was attended with considerable anxiety because of symptoms of latent uraemia, but he finally made an excellent recovery, and now, thirteen years afterwards, is fit and well, happy that he can continue his laborious toil as a ship's plater, and willing to carry on in spite of his 73 years, as long as he can find employment.

Another man of the same age had suffered for ten years from urinary trouble, which had increased so much as to interfere very seriously with his ordinary avocation as a commercial traveller. He was very ill, and five weeks had to elapse between the primary operation and the removal of the prostate, and even after that his convalescence was long and tedious, and for a time the prognosis appeared doubtful. However, after a few months his health was restored, and now, thirteen years later, at 73 years of age, he writes me that he is as well as he has ever been in his life, and has recently undertaken renewed responsibility on behalf of his firm.

Another patient, whose history I have already detailed, is so vigorous fourteen years later that at the age of 80 he is still able to walk ten miles without undue fatigue, and has travelled over a large part of the Continent since his operation.

The oldest patient on whom I have ever carried out prostatectomy was 84 years of age and had suffered for long from urinary trouble. The operation was in two stages, and he made an excellent recovery. Unhappily his illness proved so severe a tax on his wife that she succumbed to what I believe was simply the undue exertion associated with her devoted attention to the old gentleman. After his own recovery he was able to take long walks every day, and during the war he went back to his business, from which he had previously retired, and put in long days behind a shop counter. Finally, at 93, the lamp went out, having flickered for some few months, but without any definite cause, the end being like the wearing out of the machinery of life's needful little ways.

Numberless other cases could be quoted, and it is quite usual for patients to speak of "a new lease of life," "a complete restoration to health," and so on.

In some few cases the results have been brilliant in spite of the most unpromising outlook, and I am reminded of a poor fellow who lived in lodgings and who was suffering from diabetes, which for a long time deterred me from attempting the relief which prostatectomy alone offered. He was in such misery from his prostatic condition that he was willing to run any risk, and I am glad to be able to say that the operation was followed by an excellent recovery, which he greatly appreciated.

Sometimes, contrary to all canons, we carry out operations which appear to be contraindicated, and I have in mind two such cases. In both, operation was refused by surgeons who have taken a particular interest in genito-urinary disease. In one case the patient had been condemned to a permanent suprapubic drainage, but at the end of eighteen months he was so dissatisfied that he was willing to undergo any risk, and he made a very satisfactory recovery, being alive and well six years later at the age of 80. Another patient who was refused operation had reached the end of his endurance, and here again, although the circumstances appeared to weigh heavily against his recovery, he did excellently, and is alive and well years afterwards, and classed among my most grateful patients.

REFERENCE.

¹ The Importance of New Symptoms in Old-standing Disease, *Clinical Journal*, June, 1915.

RADIUM AND ITS ACTION.*

BY

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M. BECQUEREL in 1896 noticed that uranium salts affected a photographic plate through an opaque medium, and a few years later similar effects were described for thorium, polonium, and radium. All these metals emit three varieties of rays in different proportions, which are constant for each metal. Radium salts are, however, by far the most radio-active substances known, and have in recent years assumed a great importance in medicine. Indeed, the only practical application of radium at the present time is in medicine, and in this communication radium only will be considered.

Source.

In the early days radium was prepared in Austria from local ores and in France from Portuguese ores; later it was extracted in the United States, and now it is obtained practically entirely from the Belgian Congo. The ores from which it is extracted may be classified as follows:

- (1) Pitchblende, an impure uranium oxide found largely in the Belgian Congo. It contains uranium, lead, silica, iron ore, and selenium. The British Radium Corporation deal with pitchblende at Trentwith in Cornwall, but they have extracted probably not more than 10 grams.
- (2) Carnotite is a potassium uranyl vanadate, and is obtained from Colorado and Utah.
- (3) Autunite or uranite is a calcium uranium phosphate containing lead, and is found mainly in Portugal and Australia.
- (4) Betaphite found with mesothorium in Madagascar.

The history of the commercial production of radium is instructive and may be said to have passed through three phases. The first was that of the Austrian monopoly, during which radium was prepared mainly from the pitchblende of Joachimstal in Austria, and to a limited extent from the uranite of Portugal. The price during this phase fluctuated greatly. In 1905 it was marketed at from £5 to £10 per mg.; in 1909-10 at £15 to £27; and in 1912-14 at £36 per mg. The mines in the United States of America were now, however, competing, and as a result of this the price dropped in 1915 to £32 per mg., and in 1916-22 from £24 to £21. At this period the mines in the Belgian Congo were producing and made their presence felt, so that in 1923 the price further dropped to £14, and it now stands at from £10 to £12 per mg. When the mines in the Belgian Congo were in full working the American plant was shut down, perhaps because they could not compete economically with the richer Belgian ores and cheaper labour, though American authorities have stated that the reason was that as much radium had been produced as was needed. Before the Belgians operated, Europe had produced perhaps 60 grams and the United States 160 grams. If we place the total radium in the world at 320 grams we know that America possesses half or more than half of this amount. In 1923 the hospitals in the United States possessed 120 grams.

At the present time the Belgians hold the economic monopoly of radium production. In 1923 their plant produced 4 grams a month, and to the end of 1924 had produced 110 grams. But their sales did not equal their production, since in 1924 they sold only 22 grams of radium, which suggests that either their works were slowing down or they were accumulating stocks. It is necessary to appreciate these conditions in order to be clear that plenty of radium is available to meet all urgent demands provided that the price is forthcoming; it should also be remembered that the radium once produced lasts practically for all time.

The British Government has a Radium Committee now sitting to search for new radium fields in the British Empire, and within the next few years we may confidently anticipate the working of new mines, which, by competition, must inevitably lead to some reduction in price.

* Abstract of a lecture given in Cambridge.

Physical Properties.

The action of radium depends on its physical properties, and these must be referred to briefly. The modern view of the atom is that it is composed of a nucleus carrying a positive charge around which the outer electrons are distributed; these electrons are in a state of constant motion and each carries a negative charge. In a neutral atom the electrons must carry a total charge equal to the charge of the nucleus. The nuclear charge of hydrogen is 1, of helium 2, up to radium with a charge of 88, and uranium with a charge of 92.

The radium atom is remarkable because it breaks up by expelling a single alpha particle, which represents the nucleus of the helium atom, which has a charge of 2; or by shooting off an electron (beta particle). The expulsion of the alpha particle lowers the nuclear charge of the atom of radium by two units, and a substance referred to as emanation is produced which is composed of a gas, niton, allied to argon; further expulsion of alpha and beta particles produces a series of radio-active elements known as radium A, B, C, D, E, and F, until ultimately lead is formed, which is non-radio-active. No protons (hydrogen nuclei) are emitted, but only helium nuclei and electrons. Radium salts are thus being continually transformed into other metals, and it has been estimated that about half the radium will be transformed in 1,700 years. The activity of radium salts is measured by the discharge of a gold-leaf electroscope. When radium is used in mass for treatment of the patient the gamma rays only are employed, the alpha and beta particles being screened off—as, for example, by means of 1 cm. of lead. Emanation collected in capillary tubes has the same effect as radium, but its activity is soon lost and ceases in a few days.

Radium, then, has three known types of radiation: alpha particles of helium, which are readily stopped by paper or the skin; beta particles or electrons, which are stopped by 2 or 3 mm. of aluminium; and gamma rays, a type of γ ray, but four times harder than anything which can be produced by bulbs; the gamma rays are produced by the energy liberated in the expulsion of the alpha and beta particles. Radium emanation, or radon, is usually collected in capillary tubes and retains its radio-active properties for a few days only. Substances like lead-foil, or even common salt, placed in the neighbourhood of radium become coated and can be similarly used for superficial applications. Sodium chloride so treated is sometimes dissolved in water and used for injection purposes. The only radio-active substance present in the body is potassium, and the gamma rays which it emits are of greater penetrating power than those emitted by radium.

Action.

General Effects.—The rays emitted from radium exert a pronounced action on the animal body, and if the dose is sufficient may cause death. For example, if 50 or 60 mg. of the bromide are placed within 8 or 10 cm. of a mouse-cage for two days the animals die within three weeks. Guinea-pigs and rabbits after a similar exposure also die, though only after several weeks. The symptoms are loss of hair, ulcerations on the skin, especially if the rays have not been screened, nervous symptoms such as paralysis, sexual impotence, and ultimately coma. After death the central nervous system appears inflamed, the whole vascular system is dilated, the capillaries are injected, and the nerve cells in sections show signs of degeneration, though this is not necessarily a primary effect of the rays, but may be the result of capillary haemorrhages. Larger animals do not exhibit these effects in the same degree.

Local Action.—This is of great importance in surgery, because radium is largely used to destroy tissues; for general purposes emanations are to be preferred to the metal, not only on account of convenience, but of economy and safety. The various tissues in the body are not affected equally by radium; the most susceptible is the lymphatic system, including the spleen, the gonads, and, though to a smaller extent, the central nervous system. Thus the testes of small animals atrophy, the epithelium degenerates, and spermatozoa are not formed. The effect on the ovaries is shown by the production of artificial menopause. These

results are all associated with inflammatory signs, including marked dilatation of the capillaries. Developing eggs and embryos are very susceptible to the rays; bacteria, on the other hand, are affected only feebly, though the mobile forms are killed more easily than others. One explanation of the selective action of radium on certain tissues is the fact that it decomposes lecithin, and it is just those tissues which are rich in lecithin that are affected most. It has also been suggested with good evidence that the degenerative changes seen after radium are due to the toxic action of this decomposed lecithin. It may almost be accepted on broad lines that the susceptibility of tissues to radium varies with their rate of growth. Tumours are certainly more susceptible than normal tissues, rapidly growing tumours more than sluggish or benign tumours, lymphosarcoma more than carcinoma. Hence it is easy to understand that tubes of emanation buried in cancerous tissue cause degeneration of the cells and reduction in the size of the growth. In the treatment of deep-seated tumours injury to the intervening superficial tissues must be minimized as far as possible by screening off the alpha and beta rays, the alpha rays in particular having the most intense superficial effect. One other point is worth noting: the gamma rays increase the activity of the autolytic ferments, thus facilitating the absorption of dead cells. Many local conditions are now treated successfully with radium—such as rodent ulcer, lupus vulgaris, and naevi.

Systemic Action.—But besides this local action for which the surgeon uses radium, it is sometimes administered internally to produce systemic effects. Minute amounts of a salt of radium taken by the mouth are very rapidly absorbed, permeate the whole body, and are excreted as emanation and radiation by the lungs, and to a smaller extent by the urine. It is more usual, however, if a general effect is required, to take emanation either by the mouth or as an inhalation. No doubt the best method of administration for systemic effects is to use a water charged with emanation. A usual amount is half a pint daily containing 1.5 to 2 millicuries per litre. After the administration of very large amounts of emanation such as may be given as an inhalation to animals, general depression, marked dyspnoea, and death have been observed; the characteristic changes after death are widespread hyperaemia and changes in the nerve cells of the central nervous system. The indications for the employment of radium for its systemic action are still ill defined. The most successful use to which it has been put is to relieve pain in fibrous arthritis, sciatica, and tabes. The explanation of this action is suggested by the frequency with which the use of this kind of treatment is followed by a general "flare-up" of the affected tissue; indeed, the drinking of radium water may start an acute attack in any part subject to chronic inflammation. The known action of radium in producing inflammatory changes even in normal tissues is exaggerated in the case of tissues which already show chronic inflammatory effects. In other words, we are dealing with a kind of shock treatment somewhat analogous to protein-shock therapy. In chronic gout the effect is often of the same nature; in the gouty the employment of radium may initiate an acute attack, though general improvement is said to follow after some weeks. In this instance the treatment is purely palliative, since the uric acid in the blood is not affected.

Radium has met with a small degree of success in certain blood diseases. It certainly influences both the bone marrow and spleen; after the prolonged use of small doses in normal people the red blood corpuscles are said to be increased as well as the leucocytes in the peripheral circulation. Large doses have the opposite effect. There is nothing remarkable in this action; other substances have a like effect. Radium also increases the coagulability of the blood to a decided degree. In the leukaemias the local application of radium over the lymphatic glands and spleen has caused temporary improvement. It is well known that both α rays and radium diminish the leucocytes and the size of the spleen in leukaemia, though no permanent improvement in the disease occurs with either. It is interesting to note that the serum obtained from patients recently subjected to α rays, when injected into lymphocytic patients, induces a reaction.

Radium has been used also in many other diseases, such as glycosuria, arterio-sclerosis, and high blood pressure, but the beneficial results sometimes accredited to the treatment are altogether unconvincing. So far as the evidence exists, then, the action of radium is due mainly to its effect on blood vessels and perhaps on lecithin. Thus on the skin the capillaries dilate, leucocytes migrate, and

later extravasations of fluid occur. The same type of action may occur in any tissue in the body, and the effect is especially marked on chronically inflamed tissues. The changes noted in the central nervous system always begin in the blood vessels, and the nerve-cell degeneration is probably secondary, though it must be remembered that the central nervous system contains a large amount of lecithin.

THE USE OF THE CAUTERY IN OPERATIONS UPON THE STOMACH.

BY

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GASTRIC operations have often to be undertaken in ill-nourished and debilitated individuals for whom the conservation of every drop of blood is a prime consideration; more than this, such operations can only be performed with

FIG. 1A.

FIG. 1B.

any prospect of success when this primary condition of the preservation of the patient's blood is complied with. The ordinary haemostatic clamps will enable this to be done, but there are many occasions where it is not possible to gain sufficient room to apply the clamps and allow of easy suturing. This is nearly always the case with a high

because otherwise more heat is necessary owing to the cooling action of the blood stream; (2) the heating effect should be limited to within a very few millimetres of the margin. Both these conditions are fulfilled by the use of the clamps shown in Figs. 1A and 1B. The clamps are light and narrow and yet thick. They control the circulation, and the mass of metal conducts away the heat and distributes it so that the cauterizing effect is not produced beyond the clamp itself. The clamps are used as follows:

Gastro-jejunostomy.—The jejunum and posterior wall of the stomach, having been displayed and held in apposition by two traction sutures, are fixed together by the sero-serous stitch (Fig. 2). A small incision into each viscus is then made close to the suture line for the introduction of one blade of the fenestrated clamp. The blades of the clamp are closed and the visceral wall divided with the cautery through the slot. When the clamps are removed the small vessels, divided in the edge of the incision will be found to have been sealed. Now and then a single isolated larger vessel will bleed, but this is easily controlled by a ligature, and the subsequent suturing is as easy and unembarrassed by haemorrhage as in the cadaver.

Billroth I.—In performing this operation the stomach just proximal to the pylorus has often been divided between strong clamps to facilitate access to the posterior aspect of the stomach or duodenum. The sites for division of the duodenum and stomach having been selected the viscera are sutured along this line in their posterior walls. Two clamps are then placed upon the stomach and the organ divided with the cautery distal to them, as in Fig. 3. The clamp on the lesser curvature is removed, and this part of the stomach closed with suture. The duodenum, after clamping, is divided in the same way and united to the remaining part of the cut lumen of the stomach. The fenestrated clamp is not necessary for this operation.

FIG. 2.

FIG. 3.

FIG. 4.

gastrectomy or a duodeno-antrectomy, and in such circumstances a considerable loss of blood is apt to take place from the cut margins of the duodenum, stomach, or jejunum. To avoid this some surgeons have used a Paquelin cautery for section of the viscera, but the method is objectionable because of the rather wide margin of burnt and damaged tissue that is left. This necessitates a considerable in-turn at the anastomotic site, and a mass of scar tissue remains.

There are two essential conditions for making the use of the cautery for this purpose satisfactory: (1) the circulation should be controlled whilst the cautery is being used,

The Polya type of operation is performed in a similar way, two simple clamps being used for the stomach and a fenestrated clamp for the jejunum (Figs. 3 and 4).

The cautery technique has enabled me to undertake operations upon patients whom otherwise I should have considered unfit to stand a gastrectomy. It is, I believe, an important factor of safety in this difficult branch of surgery. It not only has this advantage, but the absence of ordinary clamps during the actual suturing makes this part of the operation easier to carry out, and thus leads to a saving of time.