EFFECT OF DIATHERMY CURRENTS ON METAL IMPLANTS IN THE BODY WALL

BY

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[WITH PHOTOGRAPHIC PLATE]

With the development of biologically inert metals, increasing use is being made of these in surgery, ranging from pins, plates, and cups in orthopaedic work to skull plates. Especially is this so in the repair of herniae, mainly of the anterior abdominal wall. There is thus an ever-increasing chance that patients with such metal implants may be subjected to some form of diathermy treatment—for example, for fulguration of a bladder papilloma—or have short-wave diathermy prescribed for some chronic inflammatory complaint. Usually, advice is against such forms of therapy when it is known that the patient has metal embedded in his tissues. But what are the actual chances of burning around the metal?

To a physicist this is a clear-cut problem admitting of a definite answer. Diathermy currents of two main types are used in medicine—the long-wave and the short-wave forms.

Long-wave Diathermy.—This is used for cutting the tissues, coagulating the bleeding-points, and fulgurating tumours. In this type the tissues of the body form part of the electrical circuit, and the heating effect of the current varies with the resistance of the tissue or any foreign body lying in the path of the current. If the current, which is constant, is C , then the heating will vary as $C^2 \times R$, where R is the resistance of the particular tissue or material through which the current is flowing. The resistance of the skin and fat is much higher than that of any metal implant in the path of the current, and no deleterious rise in the temperature of the metal implant would be expected.

It is conceivable, however, should the end of a wire filigree protrude through the skin and come in contact with the pad forming the indifferent electrode, that sparking with consequent burning of the adjacent skin might occur round the protruding wire. Such an occurrence is extremely improbable. A more likely happening is inadvertently touching such a filigree with a coagulating button used for haemostasis in the course of a laparotomy. In such a case, if the bulk of the implant was small, some burning of the tissues in which the metal was embedded might occur.

Short-wave Diathermy.—This is used in two forms. The first is dielectric heating. In this the body is used as a dielectric between the plates of a condenser formed by two insulated electrodes, usually made of glass. The heating effect of the current depends on the dielectric constant of the tissue or material, good heating being obtained where the value of the constant is high and where the electrical resistance of the tissue or material is also high. Since a condenser with a metal dielectric cannot be charged and the electrical resistance for metals is low relative to the values of the body tissues, no harmful heating effect would be expected in and around a metal implant when this form of diathermy is used. The other way in which short-wave diathermy currents are used for heating is by electromagnetic induction, as in the machine known commercially as the inductotherm. This is an application of the principle employed in the electric induction furnace for smelting metals. The current is led around a coil in which the part

to be heated is placed. The heating effect of the induced currents is most marked where there is a low resistance in the field. Here, therefore, the low electrical resistance of metal implants might be expected to produce a rise in temperature of the metal sufficient to cause damage to the tissues in its vicinity.

In all the above forms of diathermy as used in medicine the frequencies and wavelengths are not such as will produce any resonance effects. One point must, however, be emphasized. In the electromagnetic induction form the heating effect is enhanced if the metal can be magnetized—for example, stainless steel and similar alloys.

Experimental Tests

The effects of these three modes of application of diathermy currents have been tested on animals to ascertain how closely the results correspond with the above theories.

Eleven Wistar rats, each weighing 150 g., were used. The metals implanted were: (1) tantalum wire, diameter 0.003 in. (0.0076 cm.), length 10 in. (25 cm.); (2) stainless steel wire, diameter 0.01 in. (0.025 cm.), length 6 in. (15 cm.); and (3) tantalum wire gauze, 50 by 50 mesh, made from 0.003-in. diameter wire; a piece $\frac{1}{2}$ by $\frac{1}{2}$ in. (1.25 by 1.25 cm.) was used. In each case the right side of the lower part of the back was the site of the implant (Fig. A). The stainless steel wire was made into a coil $\frac{1}{4}$ by $\frac{3}{4}$ in. (1.9 by 1.9 cm.) and inserted just under the deep fascia of the muscles of the back. The tantalum wire was darned into the deep fascia to form a

FIG. A.—Site of implant (tantalum gauze).

patch $\frac{1}{2}$ by $\frac{1}{2}$ in. The tantalum gauze was inserted just deep to the deep fascia (Plate, Fig. 1).

After three weeks the control animals were killed—one from each of the three groups of implants—and the tissues in the region of the metal examined histologically (Plate, Fig. 2).

The rest of the animals were subjected to the various forms of diathermy, killed in 72 hours after this, and the tissues adjacent to the metal examined for any evidence of burning, naked-eye and microscopically.

Application of Long-wave Coagulation Diathermy.—One rat was selected from each of the three groups of implants. The large electrode, of silver, 1 in. (2.5 cm.) in diameter, was covered with a saline-soaked pad and applied to the skin directly over the metal implant. With the animal under chloroform anaesthesia (this was used in all cases) the diathermy button was advanced up the tail, producing coagulation. The current was passed for three minutes, during which time 2 in. (5 cm.) of tail had been

treated. *Result*:—The histological appearances were the same as those shown by the controls (Plate, Fig. 2). No burning had occurred.

Application of Short-wave Dielectric Heating.—Glass electrodes of 2-in. (5-cm.) diameter, 4 in. (10 cm.) apart, were arranged so that the current passed through the animal's body and the metal. In these experiments only tantalum gauze was used. Three animals were treated. In the first and second, current of a strength usually employed on human beings was passed for five and ten minutes respectively. No rise in general body temperature occurred. In the third rat the current, greatly in excess of that ever used on man, was passed for five minutes, at the end of which time the animal's rectal temperature was 105° F. (40.6° C.). *Result*:—No evidence of burning was found in any of the animals in the region of the implant or elsewhere.

Application of Electromagnetic Induction Heating.—Two animals were used, both of them with tantalum gauze implant. The maximum output that could be obtained from the machine (Victor inductotherm) was passed through a coil made up of three turns of wire, in the centre of which the animal was placed. In the one, the current was passed for five minutes; in the other, for ten minutes. *Result*:—No burning occurred in either animal.

Summary and Conclusions

It would thus appear to be safe to use any of the above forms of medical diathermy on patients with metal in their body walls, in the small amounts and in the form of wire of fine diameter, such as is likely to be employed in the repair of herniae. The absence of any burning in the electromagnetic induction experiments is probably due to the rapid conduction of heat away from the metal by the body fluids. It must be admitted, however, that the above experiments do not exclude the possibility of harmful effects in cases in which the metal insert is large and is implanted in relatively avascular tissue such as bone. Considerable heating might then occur and cause necrosis, especially if the metal can be magnetized, as, for instance, in the commonly employed stainless steel tri-fin nail used in the treatment of fracture of the neck of the femur.

I wish to express my thanks to Professor Cappell and Mr. W. W. Galbraith, heads of the departments of pathology and urology, for their interest and criticism of this article; to Dr. J. M. A. Lenihan, physicist to the Western Infirmary, Glasgow, for his help in the physics involved; and to Miss Ritchie, of the x-ray department, for the skiagram reproduced above.

Fifteen overseas students are taking part in a survey of British voluntary social services arranged by the British Council between June 16 and June 30. The students, who come from 11 countries, are taking long courses of study in this country in subjects which include law, local government, science, youth organization, and social science. The first visit was on June 19 to the Wimbledon Guild of Social Welfare, and St. Pancras Rotary Club entertained the group to lunch the following day. Other visits were to the British Red Cross Society on June 21, Dr. Barnardo's Garden-City Home at Ilford on June 23, and the clinic of the People's Dispensary at Ilford on June 24. On June 26 the students will visit the headquarters of the W.V.S., and in the evening they will visit boys' and mixed clubs in London. On June 28 they will be shown over the British Legion Village, near Maidstone, Kent, and the survey concludes with a visit to the National Institute for the Blind. The countries from which the students come are: Ceylon, China, Egypt, Finland, India, Indonesia, Mauritius, Norway, Persia, Siam, and the U.S.A.

HISTOLOGICAL REACTIONS TO INJECTIONS OF PROCAINE PENICILLIN IN OIL

BY

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[WITH PHOTOGRAPHIC PLATE]

Procaine penicillin, suspended in a vegetable oil and given by intramuscular injection, is now widely used. Review of the literature yields little information regarding the histological reaction of human tissues to injections of therapeutic substances suspended in oil and apparently none about the effects on human or animal muscles of procaine penicillin in oil. There are, however, reports of the changes produced by vegetable oils in animals and by penicillin in both man and animals.

This paper gives an account of the histological changes occurring in the deltoid muscles and adjacent lymph nodes of a patient who had received intramuscular injections of procaine penicillin in arachis oil. The commercial preparation used contained 300,000 units of penicillin G in combination with 120 mg. of procaine suspended in 1 ml. of arachis oil.

Clinical Summary

A foreman builder aged 67 was admitted on May 3, 1949, with subarachnoid haemorrhage complicated by a respiratory infection leading to empyema. While in hospital he was found to have an aneurysm of the aorta. His general condition deteriorated, bed-sores and a urinary infection developed, and he died on June 26, 1949.

He received the following treatment. On May 7 and 8 50,000 units of penicillin in saline were given every three hours intramuscularly on 16 occasions and then discontinued. A total of 85 g. of sulphadimidine was administered orally over the next eight days to May 15. From May 16 to 24 10,000 units of penicillin in saline were given intramuscularly three-hourly; the dose was then increased to 30,000 units three-hourly until June 2. These intramuscular injections were made into the buttocks, thighs, and deltoid regions. On June 2 procaine penicillin in arachis oil was substituted, 300,000 units being administered intramuscularly once daily and continued until June 16, when the dose was doubled to 600,000 units daily. This was maintained until the patient's death on June 26. During the last 14 days, because of extensive bed-sores over the sacrum and buttocks, many of the injections of procaine penicillin in oil were made into the deltoid muscles. No reaction was noted clinically at the sites of injection.

Pathological Findings

A necropsy which was performed on June 28 showed a wasted man with large bed-sores over the sacrum and buttocks. There were several needle-marks in a small area over both arms above the deltoid insertions. The clinical findings of subarachnoid haemorrhage, aortic aneurysm, and empyema were confirmed. Underneath the needle-marks seen on the skin of each deltoid region was an area in the muscle about 6 by 3 cm. which was greasy to the touch and showed some free oil in its deeper part. No scarring of the muscle was obvious macroscopically, but some minute cystic areas and one small haemorrhage were observed. The remainder of the muscle appeared normal. The right and left axillary lymph nodes were not enlarged: several were taken from each lateral group for microscopical examination.

Histological Appearances

From the affected areas of both deltoid muscles several blocks of tissue were examined and all showed similar appearances. The muscle was oedematous and the perimysium

E. WILSON HALL, A. GEOFFREY SHERA, AND E. OWEN FOX: CARCINOMA SIMULATING HERNIA

FIG. 1.—Inguinal gland. Mitoses, vesiculation, and inflammatory cells; remnants of lymphoid tissue. ($\times 220$.)

FIG. 2.—Inguinal gland. Oat cells. The hyper-chromatic nuclei are almost universal. ($\times 290$.)

FIG. 3.—Increased density in right lower lobe; probable bronchial carcinoma. Adhesions are present at the left costophrenic angle.

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FIG. 4.—Primary growth of right lung (lower lobe). ($\times 100$.)

FIG. 1.—Site of implant (tantalum gauze). ($\times 30$.)

FIG. 2.—Tissue reaction to implant (tantalum gauze). ($\times 200$.)

A. M. BOYD AND R. P. JEPSON: EXTERNAL ILIAC ARTERY THROMBOSIS

FIG. 1.—Case 2. Haematoxylin and eosin. ($\times 12$.)

FIG. 2.—Case 2. Haematoxylin and eosin. ($\times 60$.)

FIG. 3.—Case 2. Weigert's elastic stain. ($\times 60$.)