BALANCED-PULSE GALVANISM

APPLICATION OF A NEW PRINCIPLE AVOIDING IONIZATION EFFECTS

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Ordinary methods of galvanic stimulation are associated with certain limiting disadvantages, chiefly the ionization effects, burning or pain, inseparable from prolonged unidirectional stimulation. These side-effects often preclude the use of current strong enough to produce adequate contraction in some denervated muscles, and so seriously limit the usefulness of this form of therapy. A number of valve-operated stimulators are on the market, but they normally provide only unidirectional current and require a reversal mechanism whereby the polarity can be reversed for a period sufficient to neutralize ionization effects. The necessity for such current reversal leads to unwanted cathode or anode closing contractions.

This communication describes an apparatus for galvanic stimulation free from such disadvantages. It was evolved at the suggestion of Professor H. J. Seddon, of the Wingfield-Morris Orthopaedic Hospital, Oxford, and Dr. C. B. Heald, at that time Consultant in Physical Medicine to the Royal Air Force, and was developed and produced in the laboratories and workshops of the Royal Air Force Medical Supplies Organization at the hands of Mr. R. Brennan, A.M.I.E.E., and Mr. B. C. Elliott. In view of the principle employed, it has been called a "balanced-pulse generator," and continuous clinical trials in Royal Air Force rehabilitation units over the past two years amply confirm that this principle overcomes the disadvantages of ordinary galvanism.

The principle of balanced-pulse galvanism is that when a slow sinusoidal wave-form is produced wherein a stimulating pulse of relatively high amplitude and short duration is followed by a pulse of opposite polarity, subliminal in amplitude and prolonged in duration, and the relative values of these pulses can be equalized or "balanced," then no ionization effects are produced at the active electrode. Mathematically

$$It=iT \text{ or } It-iT=0$$

where I =intensity of stimulating pulse current, t =duration of stimulating pulse current, i =intensity of opposing pulse current, and T =duration of opposing pulse current. By keeping the opposing pulse subliminal in intensity it produces no contraction, and by ensuring an almost "square" form to these pulse waves true galvanism effects are obtained. It has also been found that by giving a sloping wave-front of some 60 milliseconds' duration to the stimulating pulse the pain effect of stimulation is normally less than with ordinary galvanism. Fig. 1 shows cathode-ray oscil-

FIG. 1

gram tracings of the current produced by the balanced-pulse generator and that produced by comparable interrupted galvanism. The stimulating pulse of the balanced-

pulse generator has the following electrical characteristics: maximum peak voltage available, 150; milliamperes at peak voltage available, 25; type of current, semi-surging (with subliminal reversal); pulse frequency, 0.5 cycle per second; pulse duration, 0.3 second; polarity, constant.

The advantages of employing this "balanced-pulse" principle are that, since ionization is eliminated, stimulation is less disturbing to the patient, who can now tolerate a current far stronger than would otherwise be bearable and so allow of a more effective muscle contraction being attained. Furthermore, with the absence of any ionic burning or even reaction of erythema, longer treatment can be given at each sitting and there is no tissue damage to prevent the early re-employment of the same motor point for further treatments.

The electrical circuit of the generator employs three valve stages and a full-wave valve rectifier to furnish the necessary D.C. power from the normal A.C. mains supply. The first valve stage produces a sinusoidal output at 0.5 cycle per second. This frequency is a pre-set one, which, however, can be altered if required. The second valve "squares" the character of this sinusoidal wave by means of a pre-set variable bias control and regulates the ratio between the pulse and its quiescent period. This ratio is arbitrarily fixed at 1:5. The third valve stage provides the balancing component, which is capable of variation through a pre-set potentiometer. This balancing component will cater with outputs up to a predetermined limit, and fresh settings are required if higher outputs are used, otherwise ionization will occur. To avoid ionization effects, settings must be so prearranged that the product of "pulse-amplitude" and "time," for both pulse and quiescent phase, are equal—i.e., the areas covered by the wave forms on either side of the datum line must be equal.

The apparatus has proved to be very simple in operation, there being only two panel controls to operate. These are an output-control knob and a meter-resistance switch whereby easily readable deflections of the centrally mounted output milliammeter may be obtained throughout the whole range of output available (see Fig. 2).

FIG. 2

Work is now proceeding to improve on the present apparatus so that, instead of a single arbitrary type of balanced pulse being produced, a selection of pulses with varying durations and at different frequencies will be available. Among other advantages this apparatus will include an improved balancing network which will be correct at all values of patient load and output-control setting. This, it is felt, should provide a greatly improved replacement for the existing types of stimulators which do not utilize this balanced-pulse principle. Such an apparatus would allow accurate calibration of doses and permit currents with the characteristics found best suited to each individual case to be recorded and repeatedly applied as necessary.

Summary

A valve-operated stimulator is described whereby interrupted galvanism, free from ionization side-effects, can be given. The principle employed in the production of the current ensures freedom from ionic burning at the active electrode without the use of any current-reversal mechanism, and treatment from this source of galvanism is less painful and avoids tissue damage at the motor point.

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Medical Memoranda

Coronary Artery Disease, Hypertension, and Hypercholesterolaemic Xanthomatosis

It is our purpose to draw attention to a well-defined clinical syndrome of related cutaneous and cardiac disease, and to illustrate the condition by reference to two cases. Substernal discomfort related to effort, or vague dyspeptic symptoms occurring in patients showing cutaneous xanthomata, should be carefully investigated.

Atheroma of the coronary arteries is undoubtedly the commonest cause of angina pectoris or cardiac infarction, and is occasionally associated with a hypercholesterolaemic cutaneous xanthomatosis. The precise relationship in man of a raised blood lipid and atheroma of the arteries is not yet clear. It may be that primary cutaneous xanthomatosis of the hypercholesterolaemic type with atheroma represents a disturbed intracellular lipid metabolism (Thannhauser, 1940). It is important to recognize this syndrome, as it may appear in relatively young persons and has a grave prognosis (*British Medical Journal*, 1939). The following two case histories are believed to be examples of this condition.

CASE 1

A housewife aged 42 had had scarlet fever at the age of 6, but had no history of any other significant illness. Her father, aged 65, was hypertensive and had experienced two hypertensive cerebral attacks. The patient had made a slow recovery from a forceps delivery 17 years before. Following this she began to have flatulent dyspepsia and substernal discomfort.

When seen by a consultant physician four years previously she described two distinct thoracic pains: a burning sensation in the substernal region which might come on at any time, and a substernal discomfort which gripped her chest and was brought on by exertion, forcing her to rest. For these symptoms cholecystectomy was performed 12 months later. She had observed the condition to be progressive. During the three months before admission to hospital she had been forced to rest when walking up the slight incline to her house. There were no other significant symptoms.

The positive findings on examination were: xanthoma palpebrarum without other skin lesions; blood pressure of 200/130; minimal retinal arteriosclerosis; and normal cardiovascular outline and excretory pyelogram. Examination of the oesophagus with barium did not show any evidence of cardiospasm. The electrocardiogram was within normal limits. The blood non-protein nitrogen was 27-30 mg. per 100 ml., and the serum cholesterol 420-500 mg. per 100 ml. The urine was entirely normal, as was a modified urea-concentration test (McGeorge, 1945). A Smithwick lumbo-dorsal splanchnicectomy was performed.

CASE 2

A housewife aged 48 had suffered from scarlet fever complicated by otitis media at the age of 3, and a hysterectomy for fibroids had been performed at the age of 46. Her mother had died at the age of 69 from coronary artery disease. An interesting family history of xanthomatosis was elicited, two female first cousins (on the paternal side), aged 48 and 50, being affected by xanthomatosis of the skin of a few years' duration. The patient did not smoke or drink.

Three and a half years before admission she began to experience pain in the chest and palpitation; for the previous six to nine months the pain had become more severe. It was classically anginal in type, was brought on by slight exercise, excitement, meals, or cold weather, and was relieved by rest or glyceryl trinitrate. She had never had pain at rest or any prolonged thoracic pain. She told, in addition, of pain in the neck and jaws, right shoulder, and arm. She complained of flatulence but not nausea or vomiting. Menopausal symptoms had followed the hysterectomy.

The patient showed bright yellow xanthomata at the inner canthus of both eyes. The heart was normal in shape, size, position, and sounds; the blood pressure was 210/130; there was no albuminuria; the electrocardiogram was normal; the patient's serum cholesterol was 630 mg. per 100 ml. A lumbo-dorsal sympathectomy proved fatal. At necropsy advanced coronary and aortic atheroma was observed.

We wish to acknowledge the guidance of Prof. Henry Cohen and Dr. E. T. Baker-Bates.

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Torsion of the Gall-bladder

Torsion, or volvulus, of abdominal organs accounts for a fair proportion of acute emergencies. Ovarian cysts and the sigmoid colon are the commonest sites, but few, if any, abdominal organs are immune. The gall-bladder rarely undergoes torsion. When it does, early recognition of the need for operation is vital. Recovery is the rule after operation during the first 48 hours, but a high mortality attends operation delayed beyond this period.

CASE REPORT

A man aged 67 was admitted to Redhill County Hospital, Edgware, on June 15, 1946. He complained of colicky abdominal pain of increasing severity which had started on the previous day. He had vomited once. The bowels had not been opened despite the administration of an enema. He had had no similar symptoms previously and his health had been fairly good, though he had had some indigestion.

On examination the patient was pale and appeared toxic and rather senile. The temperature was 97° F. (36.1° C.), pulse 100. The tongue was very dirty. The heart was enlarged. There was board-like rigidity of the whole abdominal wall, with pronounced tenderness which was maximal in the right hypochondrium. No mass was felt.

Operation.—In the evening of the day of admission the abdomen was opened by an upper right paramedian incision. The black shiny fundus of the swollen gall-bladder (see accompanying photograph) immediately presented. Further inspection revealed a complete torsion of the neck and patches of gangrene on the body of the gall-bladder. The neck was untwisted and cholecystectomy was performed with great ease. The abdomen was closed without drainage.

Photograph of black distended gall-bladder showing site of torsion.

Post-operative Course.—For the first two or three days evidence of toxæmia persisted. Dirty fluid was aspirated from the stomach through a Ryle's tube, and 1 pint (570 ml.) of plasma and 1 pint of glucose-saline were given intravenously. Subsequently the patient improved rapidly. He was allowed up on the tenth post-operative day and left hospital in good health a week later.

COMMENT

Torsion of the gall-bladder occurred atypically in a male patient. The clinical picture conformed with the usual descriptions, but tenderness and rigidity of the abdominal wall prevented the palpation of a tumour. The gall-bladder had a short attachment by its neck to the liver. There were no gall-stones.

Torsion of the gall-bladder may be diagnosable pre-operatively if a rounded mobile swelling varying in hardness is palpable in the right hypochondrium; otherwise the condition is apt to be mistaken for acute cholecystitis, perforated duodenal ulcer, or acute appendicitis. Should non-operative treatment be contemplated on the basis of one of these diagnoses, the possibility of the existence of a strangulation, or a twisted gall-bladder, *inter alia*, should be carefully considered, for in such conditions delayed operation greatly jeopardizes the life of the patient.

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