PSYCHOLOGY

Parameters of Electric Shock relevant to Electro-convulsion Therapy

IN an earlier communication[1], I reported a finding indicating that the power dissipated in the subcutaneous tissues, where the receptors lie, is the parameter most relevant to the determination of threshold electric shocks. This led to the assertion that it would be more reasonable and safer to control wattage rather than voltage or current when using electro-convulsive therapy. As a result of correspondence with Dr. G. R. Hawkes, of the U.S. Army Medical Research and Development Command, I am persuaded that this assertion is misleading. A more accurate conclusion would have been that, although the standard practice of controlling voltage is less safe than controlling the wattage, it would probably be safer still to control current under the conditions obtaining in a mental hospital.

Two assumptions need to be borne in mind to reach this conclusion. First, by far the greater part of the impedance of a biological circuit occurs in the stratum corneum, very little being met in the subcutaneous tissues. Secondly, this impedance is a function of the nature of the contact made between the electrodes and body surface. As was pointed out in the original communication, the use of electrode jelly reduces this source of impedance to a marked extent.

Given these conditions, the relative merits of the three types of stimulation are readily compared. With a constant voltage stimulus a halving of the skin impedance virtually doubles the current. If the impedance of the subcutaneous tissues remains constant, then the power dissipated in these tissues will be quadrupled. Under constant power conditions, halving of the skin impedance produces an increased current and a reduced voltage, so that the power dissipated in the subcutaneous tissues is only doubled instead of quadrupled. With a constant current stimulus changes in the skin impedance cannot affect the power dissipated in the subcutaneous tissues, provided that the impedance of this part of the biological circuit remains unchanged.

If the skin impedance remains constant and that of the subcutaneous tissues varies, then a different picture emerges. A doubling of the impedance in the subcutaneous tissues will virtually double the power dissipated in these tissues under constant voltage, constant power, or constant current conditions, leaving little to choose between them in this respect.

All the foregoing, however, is predicated on the assumption that the impedance of the subcutaneous tissues forms an insignificant fraction of the total impedance of the biological circuit. Most evidence so far favours this assumption, although there may be special circumstances in which it does not hold. Since we know very little about the distribution of energy within a biological circuit when an external E.M.F. is applied via the intact skin a note of caution is in order. In particular, the capacitative changes that occur under these conditions are of uncertain magnitude and locus. It is, therefore, possible that with some kinds of a.c. input, and on the make-and-break with a d.c. input, there may be brief periods in which this assumption is invalidated.

If at any time the impedance of the subcutaneous tissue does form a preponderant part of the load, and if this impedance varies while skin impedance remains constant, then the constant power stimulus would provide better control of the power dissipated in the subcutaneous tissues than either a constant voltage or constant current stimulus. The odds are that these special conditions prevail less frequently when electro-convulsive therapy is being used than those conditions contingent on the two basic assumptions discussed. It follows that the patient is more likely to be safeguarded by a constant current stimulus than by a constant power stimulus, although it remains true that the constant voltage stimulus in general use is the least satisfactory of all in this respect.

If, under constant voltage conditions, electrode jelly is used either more copiously or in fresher condition in a later session of a series of electro-convulsive therapy treatments, then the voltage that was appropriate earlier in the series will be too great when the load is reduced at the skin surface. If dry electrodes are used, then the degree to which the patient is sweating will introduce a similar uncontrolled variable and expose the patient to the same danger of an unintentionally high level of shock in terms of the power dissipated in the brain.

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[1] Green, R. T., *Nature*, **194**, 1303 (1962).

Electrical Stimulation of Pain and Touch Systems

To take best advantage of cutaneous channels for communication, information must be translated into a form compatible with perceptual properties of the touch sense. To find whether such channels are effective other than as providing mere warning information or slow transliteration of speech, one needs systematically to vary cutaneous stimuli along temporal and spatial dimensions to determine the resolving power of the nervous system for complex patterns of cutaneous stimuli. In contrast to vibration, direct electrical stimulation of the skin has several advantages, but the disadvantage that pain ordinarily accompanies electrical stimulation of hairy body regions. The purpose of this investigation was to determine conditions of painless electrical stimulation of touch, by defining the stimulus conditions which affect pain and touch thresholds.

Touch and pain thresholds as peak current were measured in two experiments as a function of: (1) the number of brief electric pulses, from one to 20; (2) the rate of pulse repetition, 10–250 pulse/sec, on eight body regions, including hairy and hairless tissues[1]. The anodal pulses, delivered through a constant current stimulator, were 0·5 msec in duration at half-peak.

Pain thresholds were rendered relatively reliable by training procedures. One result was relaxed, attentive observers unreactive to threshold pain, in effect, a functional separation of cutaneous pain thresholds from effects of pain reaction. Also, thresholds were made stable by sufficiently long interstimulus and inter-threshold times, which minimized cumulative effects of stimulation.

Pain thresholds and touch thresholds were a decreasing hyperbolic function of the number of pulses in a stimulus train, indicating nearly linear integration of current pulses at different rates by pain and touch. Also, pain and touch thresholds fell at different rates with increasing repetition rates from <10–100 pulses/sec. It was concluded that stimulation of touch with 0·5 msec current pulses can be reliably pain-free over much of the surface of the body given low repetition rates and low pulse number, because of the shorter time course of integration for touch than for pain.

Pain threshold current in hairy tissues was markedly different on electrode sites with high pain sensitivity relative to touch compared with those with low relative pain sensitivity; corresponding touch thresholds were nearly the same. Thus differences in the likelihood of stimulating pain on hairy tissues were primarily due to pain sensitivity differences, rather than touch sensitivity differences.

The perceptual nature of threshold pain was often described as sting on hairy tissue, dull pain on hairless regions. It was concluded that sting does not depend on the presence of hair or associated musculature, but is