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Impedence Measurements during Electroconvulsive Therapy

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Abstract

Impedence measurements were conducted in 49 male patients during electroconvulsive therapy. Wide fluctuations in impedence between and within patients across occasions were recorded. Age seemed to positively influence the impedence, whereas the occasion at which ECT was given and the voltage used, negatively influenced the impedence. Measurement of electrical energy dose using joules was found to have large variations and thus may not accurately reflect the energy delivered to the brain tissue.

Key words -
Electroconvulsive therapy,
Impedence

The clinical efficacy of ECT is proven both in depression [1] and schizophrenia [2]. There is also evidence that it produces fewer side effects than imipramine in depressives [3] and supresses the extra-pyramidal side effects of neuroleptics [4] used in schizophrenia. From an extensive review of its CNS toxicity it was concluded that there was little evidence to support a permanent CNS damage with ECT [5]. That CNS toxicity is due to the electricity, while the clinical efficacy is due to the seizures [6] has lead to introduction of low energy pulse ECT. Although there is a suggestion that clinically low energy pulse ECT may be less potent [7], that it causes lesser degree of CNS toxicity has been recently demonstrated [8]. In the light of this debate, energy measurements during ECT was deemed necessary. To do so, the impedence offered between the two scalp electrodes has to be measured. Following are our observations on such measurements during electro-convulsive therapy.

Material & Methods

Measurements were made on 49 male patients (Age range 17-60 years, mean 31 years, SD 11.4). They received on an average 7.2 treatments each (SD 2.7, range 4-12). For 11 patients measurements could be made on their first ECT occasion, while for the other 38 patients the first possible measurement was recorded on subsequent ECT occasions (2nd to 9th). For 30 patients measurements could be repeated at least once at an interval of three or more ECT occasions. ECTs were administered during morning hours (9 AM to 12 Noon). Thiopentone (150-200 mgm), succinyl-choline (15-30 mgm) and atropine (0.65 mgm) were used intravenously for modification. Forceps electrodes each of 30 mm diameter were applied over the fronto temporal areas bilaterally. Electrode jelly used for recording EKG was used for contact.

A transformer type of ECT machine which generates a 50 Hz sinewave at a constant present voltage between 90 to 160 volts (in 8 steps of 10 volts each) for a constant present time between 0.3 to 1 sec. (in 8 steps of 0.1 sec each) was used for delivering the stimulus. One of the ECT electrodes was connected to the machine in series with a two Ohm resistor. The voltage drop across this known resistor was recorded on an oscilloscope. From this value the current in the circuit was measured using Ohm's law. Thus at any given voltage the current in the circuit is negatively related to the interelectrode impedence. As the voltage drop across this standard resistor was never more than two volts, the value of the voltage setting used for delivering the stimulus (90 to 160 volts) was used for all further estimations. From this the interelectrode impedence, joules of energy delivered and the millicoloumbs of charge passed were estimated for each patient on each occasion. Measurements made were steady state values. All estimates were made for stimulus intensities which produced a major convulsion. Pupillary reflexes, planter movements, clonic movement of frontails and piloerection were used as indices of major convulsion when the muscle relaxation was deeper. The duration of convulsion was not recorded.

Results

Range, mean and standard deviation of stimulus parameters for 49 patients as measured on their earliest possible ECT occasion are represented in table I. The modal interelectrode impedence was 310 Ohms. Further distribution of impedence values are given in the Table II. 31 patients (63 percent) had an impedence below 350 Ohms. Age had a non-significant but positive correlation with this impedence value (r= 0.1578). Age also had a similar non-significant positive correlation with the voltage setting using (r=0.1307) and the voltage had a negative correlation with impedence, (r=-0.1278). Interestingly both the voltage used as well as impedence, were related to the occasion of ECT at which the measurements were made. As expected with the latter occasions, impedence decreased (r=-0.3450), while the voltage had been increased (r=0.2660). As age had positive correlation over the latter to indices i.e., voltage and impedence, partial correlation of voltage on impedence keeping age as constant yielded a slightly higher negative correlation (r=-0.1516). Age had little influence over joules requirement (r=0.0012).

Table I - Range, Mean & Standard Deviation (SD) of the measurements obtained in 49 patients

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Table II - Distribution of impedence measurements on patients

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(Numbers in parantheses are percentages)

As the number of ECT occasion had an influence on some of the indices measured, the values for eleven patients in whom measurements were carried out on the first occasion were analysed. The results were again similar. Age had positive correlation with impedence and voltage (r=0.1313 and 0.2481 respectively). Voltage had a negative correlation with impedence (r=-0.1283) partial correlation of voltage on impedence keeping age as constant yielded a higher negative correlation (r=-0.1675).

In 30 patients measurements could be repeated on at least one other occasion at an interval of three or more ECTs. The impedence had decreased significantly (t=2.4984, df=29, $p < 0.05$), by an average of 42.97 Ohms. One patient had an unchanged impedence, twenty had shown a reduction upto a maximum of 285 Ohms, while nine had shown an increase upto a maximum of 164 Ohms. The mean change in voltage was zero (SD=12.09). Voltage was unchanged for seventeen patients. In the seven patients for whom the voltage was decreased, one had an increased impedence while six had decreased impedence and in the six in whom the voltage was increased, four had increased while two had decreased impedence.

Discussion

The wide range of impedence measurements recorded during electroconvulsive therapy support an earlier finding [9]. That almost twice the values noticed in the range could not have resulted from the differences in biological structures alone, e.g. thickness of vault. More so as within patient variation from occasion to occasion which was from -285 to +164 Ohms, again exclude patient variable alone as being responsible. Thus outside patient variables like scalp preparation, application of electrode jelly, placing and pressure on the electrodes which essentially vary from patient to patient and within the same patient from occasion to occasion, should be held responsible. These artefactual changes are more likely as the electrodes were held manually and not fixed. The personnel involved in placing electrodes also differed. At the moment there is no way of measuring these variables. The role of psychotropic drugs were not considered as they affect mainly the excitability of the CNS tissue i.e., convulsive threshold.

This wide degree of variation in the interelectrode impedence consequently resulted in a similar range of variation in other parameters like the joules, current and millicoloumbs. Thus as has been suggested earlier [9], [10] use of joules for measuring the electrical energy administered may be erroneous as the amount of energy lost at the electrode skin interface cannot be estimated nor can the inter-electrode resistance be predicted within a reasonably narrow range of values. Therefore, use of millicoloumbs (current in milliamperes × duration in seconds) as in current constant ECT machines will be more accurate in indicating the amount of charge delivered to the brain tissue. As stated by Meletzky [11] an apparatus which can deliver constant current into wide range of impedences with a present go-no-go limits, should be useful for this purpose.

From the other factors analysed interesting trends emerged. Age had a non-significant but positive correlation to the impedence values and it also positively influenced the voltage setting required for inducing a convulsion. When this age factor was corrected voltage seemed to negatively correlate with the impedence values. Maxwel [12] reported data which support a nearly similar finding. Increase in voltage upto 90 volts lead to rapid drop in tissue resistance which remained a plateaua between 90 and

160 volts. Similarly Gordon [9] has mentioned that at voltages recorded from EEG electrodes in microvolts, the resistance records as high as 5000 Ohms while during electrocution in the electric chair at 950 volts the resistance drops to as low as 63 Ohms. If only the other inter-individual and interoccasion variables could be kept constant this relationship between voltage setting and impedence could have been better studied.

The impedence values had decreased in over 60 percent of individuals at subsequent occasions with a group mean reduction of 42 Ohms, although the mean change in voltage setting for the group was zero. No relationship however, emerged between the voltage change and change in direction of impedence. Contrarily, of the seven in whom voltage was decreased impedence increased only in one while six others showed a reduction. Whereas of the six in whom the voltage was increased impedence reduced only in two while in four others it increased. Thus we were unable to establish the negative relationship between voltage and impedence unequivocally. Assuming such a relationship, a joule constant machine which presupposes a constant impedence, may deliver higher charge at a high voltage-short duration stimulus as against a low voltage-long duration stimulus. The clinical implications of such permutations need further scrutiny.

Again with increasing ECT occasions the impedence values seem to fall (r=-0.3430) and within individuals too a mean reduction of 42 Ohms occurred on subsequent occasion. That one shock may diminish the interelectrode impedence for the next is partly supported by our findings, although a disagreement has been voiced earlier [11]. This study essentially examined the steady state electrical parameters during the entire therapy procedure. The changes in impedence and other electrical energy values mentioned here are the changes from one therapy session to other within and across patients. The study of transient wave forms of current would give a measure of changes in impedence during single therapy session. These transients reflect the inducting and capacitance properties of the anatomical structures between two electrodes.

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