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EEG Monitored ECT

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Summary: EEG monitored ECT was administered to 20 patients, 12 females and 8 males. One hundred and fifty-six treatments were given (mean 7.8 treatments/patient), and the relation between clinically observed seizures (COS) and the cerebral patterns of convulsions (EPC) was compared. If clinical observation alone had been used, restimulation would have been necessary in 43 per cent of the treatments, whereas restimulation actually was done in 9 per cent. Similarly, too violent convulsion patterns would have been ignored in 5 per cent of the treatments.

Electroconvulsive therapy (ECT) is the most effective treatment of depressive illness of endogenous type (Royal College of Psychiatrists, 1977). Immediate side-effects of ECT are few (Greenblatt *et al*, 1964); the most troublesome is a temporary cognitive disturbance, and there is evidence that this is related to the amount of electrical energy applied (Ottosson, 1960). Convulsions are a necessary element of the antidepressive effect of ECT. A long convulsion, as measured by EEG, has been shown to be more effective than a short one, and the therapeutic effect is related to the convulsive activity (Cronholm and Ottosson, 1960).

Since early 1980 we have carried out EEG monitored ECT. From the very beginning, the use of this new technique showed a discrepancy between the quality as well as the quantity of the clinically observed seizures (COS) and the EEG recorded patterns of convulsions (EPC). The absence of COS, which would have led to further stimulation and consequently increased dosage of current, was nevertheless sometimes accompanied by acceptable EPC. This led to the present study on the relation between clinically observed seizures and the cerebral patterns of convulsions.

Method

The study was conducted on a consecutive series of patients undergoing ECT, and the only criterion for exclusion was a lack of one of the two paired observations (COS and EPC) in a series of ECT. In this way 20 patients (12 females and 8 males) were selected. Fifteen of the patients were suffering from manic-depressive psychosis.

Except for two, all patients were given ECT thrice weekly. The patients were premedicated with atropine s.c.; sodium pentothal was used as general anaesthetic agent and suxamethonium as muscle relaxant. Artificial respiration with 100 per cent oxygen was administered. These procedures were carried out by staff from the department of anaesthesia. All patients were stimulated with the MECTA® apparatus using ECTRON® electrodes soaked with ECTRONOLYTE® in aqueous solution, in bilateral fronto-temporal placement. Before stimulation skin grease was removed with acetone to keep the impedance of skin surface as low as possible. When muscle fasciculations due to the suxamethonium had ceased, the ECT was administered and an acceptable EPC was sought.

MECTA® is the first ECT device, known to us, to be fully independent of the quality of the mains. The output is fixed at 800 mA and is given as ultrashort square waves A.C. which can be varied in frequency (20-70 Hz), in pulse width (0.15-1.5 msec) and in pulse duration (0.5-2.0 sec). In this way application of an individualized amount and configuration of current is possible. The MECTA® apparatus is provided with a two-channel chart monitor for EEG and ECG, and a built-in control of patient impedance. A special circuit ensures that ECT takes place only if this impedance is between 200 and 1400 ohms, so that the applied amount of current, within reasonable limits, is consistent with intention. The range of outputs is 0.57-80.6 Watt-seconds (specification of the device). During ECT, patient impedance and dosage level are automatically recorded on the EEG monitor chart and by using a special dosage normograph the applied electrical energy in Watt-seconds can be calculated. Cerebral activity is recorded bipolarly on one channel, the two electrodes being placed frontally.

After ECT the quality and quantity of EPC were evaluated (Table I). The quality of the convulsion

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TABLE I

Evaluation of EEG recorded patterns of convulsions

Quality of EEG	Explanation	Clinical procedure
O	No pattern of convulsion	Repeated electrostimulation with 50–75 per cent increased dosage within the same anaesthesia.
T	Threshold convulsion, see Fig 1A.	Repeated electrostimulation with 25–50 per cent increased dosage within the same anaesthesia.
TA	Slow starting, but acceptable pattern of convulsion, see Fig 1B.	Await EEG of next ECT before possible increased dose.
A	Acceptable pattern of convulsion, see Fig 1C.	
S	Supraconvulsion, see Fig 1D.	Decreased dosage at next ECT.

Duration is measured in seconds on the EEG recording.

TABLE II

Clinical evaluation of ECT

Quality of seizures	Explanation	Procedure if ECT were carried out under clinical estimation
O	Absence of visible seizures.	Repeated electrostimulation with 100 per cent increased dosage within the same anaesthesia.
G	"Gooseflesh", i.e. contraction of mm erecti pilores.	Due to uncertainty of cerebral convulsion pattern, repeated electrostimulation with 100 per cent increased dosage within the same anaesthesia.
(+)	Few and unacceptable contractions in one or few muscles.	Due to uncertainty of cerebral convulsion pattern, repeated electrostimulation with 100 per cent increased dosage within the same anaesthesia.
+	Light but acceptable seizures.	
++	Acceptable seizures.	
+++	Seizures too violent.	Decreased dosage at next ECT.

Duration is measured to the nearest five-second interval.

pattern was also estimated during the treatment with a view to possible restimulation. Only TA and A are acceptable patterns of convulsion; a too violent pattern (S) is unacceptable because unnecessary electrical energy is administered thereby increasing the risk of temporary cognitive disturbances (Ottosson, 1960) and calls for a decreased dosage at the following treatment. Qualities O and T, requiring restimulation with increased dosage during the same anaesthesia, were also unacceptable. The duration of EPC was measured in seconds from the EEG record.

During ECT the quality and quantity of COS were also evaluated (Table II).

Results

Paired observations were recorded on 150 treatment occasions (a mean of 7.8 treatments per patient). The qualitative evaluations are shown in Table III.

Of the 150 treatments, 119 were acceptable by the EPC criteria but the clinical assessment of the seizure was judged to be uncertain or absent on 65 occasions. Of these 65 clinically unacceptable seizures, 53 (82 per cent) had seizures acceptable by the EPC criteria, and of the 31 occasions where there was a complete absence of an observed seizure, 22 (71 per cent) had nevertheless an acceptable EPC; 87 per cent of the seizures classified as G had an acceptable EPC and

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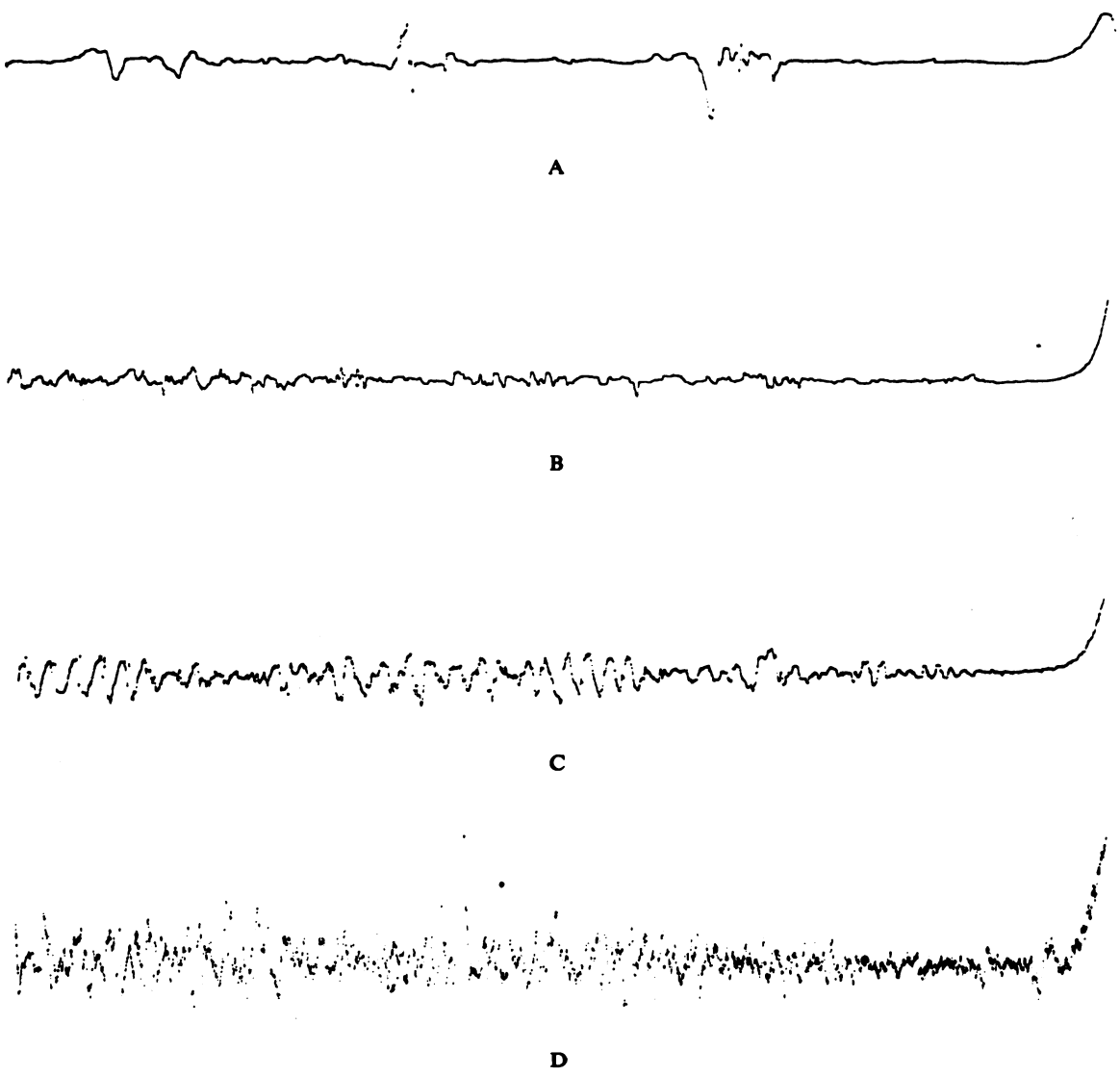


FIG.—Patterns of EEG recording. 1A—threshold pattern of convulsion (T); 1B—slow starting but acceptable pattern of convulsion (TA); 1C—acceptable pattern of convulsion (A); 1D—supraconvulsion, i.e. too violent pattern of convulsion (S).

all of the (+) seizures were acceptable by the EPC criteria.

Of the 75 clinically acceptable seizures, which were recorded on 50 per cent of the treatment occasions, two (3 per cent) had seizures which were too slight and eight (11 per cent) had seizures which were too violent by the EPC criteria. When the seizures were too violent on clinical observation a supraconvulsion was recorded on nine of the ten occasions. Of the 119 seizures which were judged to be acceptable by EPC

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TABLE III

Quality of cerebral patterns of convulsions (EPC) compared with clinically observed seizures (COS)

		Clinical evaluation (COS)							
		Unacceptable			Acceptable		Unacceptable		
EEG quality (EPC)		O	G	(+)	+	++	+++	Total	Grouped total
Unacceptable	O	3						3	14 (9.3%)
	T	6	3		1	1		11	
Acceptable	TA	10	4	1	9	2		26	119 (79.3%)
	A	12	16	10	32	22	1	93	
Unacceptable	S				2	6	9	17	17 (11.3%)
Total		31	23	11	44	31	10	150	
Grouped total		65 (43.3%)			75 (50.0%)		10 (6.7%)		150

T = threshold; TA = slow but acceptable; A = acceptable; S = supraconvulsion.

criteria, 53 (45 per cent) had seizures which would have resulted in restimulation had reliance been placed on clinical judgement alone. The overall relationship between EPC and COS is expressed by $\chi^2 = 104$, 20 df, $P < .001$ which indicates considerable disparity between the two methods of assessing seizures during ECT.

On those occasions in which a COS of the + or ++ pattern was observed, the relationship between the duration of the COS (range: 5-60 seconds) and the EPC (range: 17-140 seconds) was examined; the correlation was found to be $r = +0.51$ ($P < .001$) which indicates that only 26 per cent of the variance of the COS duration could be accounted for in terms of the EPC duration; the explanation of this finding is probably related to the effects of the anaesthetic and muscle relaxant drugs in modifying the duration of the seizure.

Finally the relationship between the duration of the seizure as recorded on the EEG and the pattern (TA, A or S) was examined. The mean durations (standard deviations) were as follows: TA, 39.5 (16.3) secs); A, 53.8 (37.6) secs; and S, 50.1 (18.1) secs. The significances of the differences between these groups are: TA/A, $t = 2.84$ $P < .01$; A/S, $t = 0.62$ NS; TA/S, $t = 1.91$ NS.

Discussion

On the fact alone that an acceptable EPC was obtained without clinically observable reactions, we have demonstrated that in ECT the concordance between the EEG recorded pattern of convulsions and the clinically observed seizures is poor, qualitatively as well as quantitatively. Even in the clinically acceptable groups, with fair qualitative concordance, the correlation between durations only permits the statement that an acceptable cerebral pattern of convulsion had arisen with a duration alike or longer than that of the clinical seizures. Cronholm and Ottosson (1960) found a long cerebral pattern of convulsion to be more effective than a shorter one, and this study indicates that the accumulated durations of cerebral patterns of convulsion is related to recovery; we therefore recommend that the duration of clinically observed reactions should not be used in investigations concerning the effect of ECT.

If clinical observation only had been used in this study, 67 (43 per cent) of the given 156 ECTs would have been restimulated, whereas this would have been necessary in only 14 (9 per cent) of ECTs using EEG evaluation. Eight convulsion patterns (5 per cent) that were too violent would have been ignored. This demonstrates that an unnecessary amount of energy is applied to the patients when ECT is carried out on the basis of clinical evaluation. Ottosson (1960) found that the long term side-effects were related to the electrical energy applied. The aim of ECT must be to produce the longest possible cerebral pattern of convulsion using the smallest possible amount of energy. This study shows that one kind of cerebral pattern of convulsion fulfils this condition (A), and this has already been partly demonstrated by Kirstein and Ottosson (1960).

This indicates that the quality of the cerebral

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pattern of convulsions is a major factor in maximal effect combined with minimal side-effects. The study shows that we should revise the evaluation of both the EEG recorded and the clinically observed seizures. Because of the shorter duration of the TA patterns of cerebral convulsion, they should be avoided. Due to the relatively high percentage (here exclusively TA patterns) of acceptable EPCs in the clinically observed groups of 'gooseflesh' and uncharacteristic reactions, these could be accepted clinically as indicating acceptable cerebral convulsions. We should, therefore, recommend users of ECT equipment without EEG monitor to accept any such clinical reactions as acceptable. Muscle fasciculations due to the muscle relaxant must not be confused with the uncharacteristic reactions.

The variation in the quality of EPC in the series of ECT was often greater than desirable in spite of an unchanged setting of the ECT device. We attribute some of this variance to variation in patient impedance. The amount of current applied (energy) is expressed in: Watt-seconds = Joules = Volts × Amperes × seconds, where Volts = Amperes × Ohms.

Variation in patient impedance results in variation of applied energy due to the fixed amperes. The ECT device is provided with a circuit blocking the treatment when patient impedance is not within the limits acceptable for the device, but within these limits the amount of applied energy can nevertheless vary more than 50 per cent. In our experience factors influencing the impedance are pressure at the electrodes, the area of contact surface and removing grease from the skin. The type of electrodes used can also influence the impedance. Relatively uncontrolled amounts of energy can be applied to patients from an apparatus without an impedance control circuit. The administration of the anaesthetics may also influence the quality of EPC. This was given by different anaesthetists and because of this, the rate of infusion of the anaesthetic probably varied.

The ultimate conclusions are that ECT should be monitored by EEG and that a circuit controlling patient impedance should be built into ECT devices.

References

CRONHOLM, B. & OTTOSSON, J. O. (1960) Experimental studies of the therapeutic action of electroconvulsive therapy in endogenous depression. *Acta psychiatrica et neurologica Scandinavica.* Supplementum 145, **35**, 69–97.

GREENBLATT, M., GROSSER, G. H. & WECHLER, H. (1964) Differential response to hospitalized depressed patients to somatic therapy. *American Journal of Psychiatry*, **120**, 935–43.

KIRSTEIN, L. & OTOSSON, J. O. (1960) Experimental studies of electroencephalographic changes following electroconvulsive therapy. *Acta psychiatrica et neurologica Scandinavica*, Supplementum 145, **35**, 49–65.

OTTOSSON, J. O. (1960) Experimental studies of memory impairment after electroconvulsive therapy. *Acta psychiatrica et neurologica Scandinavica*, Supplementum, 145, **35**, 103–27.

ROYAL COLLEGE OF PSYCHIATRISTS (1977) Memorandum on the use of electroconvulsive therapy. *British Journal of Psychiatry*, **131**, 261–72.

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