The results of this small series are encouraging, and seem to merit the further trial of hydrocortisone in de Quervain's disease and in tenosynovitis occurring at other sites.

I wish to thank Dr. A. C. Boyle for permission to quote these cases and for his interest and many helpful criticisms at all stages of the survey; Mr. Philip Wiles and Mr. P. H. Newman for kindly referring cases; and Roussel Laboratories for generously supplying all the hydrocortisone used.

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EFFECTS OF MODIFIED E.C.T. ON THE ELECTROCARDIOGRAM

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There have been several investigations into electrocardiographic changes during electric convulsion therapy (E.C.T.). Most of them were carried out before the use of muscle relaxants, and consequently the records could be taken only after the end of the convulsion. The purpose of this paper is to record our findings in patients whose convulsions were attenuated by muscle relaxants to such an extent that the electrocardiogram (E.C.G.) could be recorded during the convulsion, thereby providing further information regarding the safety of the procedure.

Method

Relaxation was achieved by the use of suxamethonium chloride, but, as the slightest movement of the limbs during stimulation interfered with the tracings and made their interpretation difficult or even impossible, doses far in excess of those normally used for routine treatment had to be employed. Four milligrams of suxamethonium per stone (0.6 mg. per kg.) of body weight gives adequate attenuation of the fit for routine treatments in the majority of patients, but for our purpose it was necessary to administer up to 10 mg./stone (1.6 mg. per kg.) to obtain the degree of relaxation required.

Every patient was fasted for at least four hours and was given atropine, 1/100 gr. (0.65 mg.) hypodermically half an hour before treatment.

After explaining to the patient the nature of the investigation, a resting E.C.G. was taken. (At the beginning of the investigation the three standard leads were recorded on a three-channel Elmquist; later, a direct-writing Cambridge electrified cardiograph was used and Lead II recorded.) A "sleep dose" of intravenous thiopentone was administered slowly, 0.25 g. seldom being exceeded. It was followed immediately by a large dose of suxamethonium from a different syringe, but through the same needle. As soon as apnoea developed the lungs were inflated with oxygen through a face-mask and bag. A second recording was then taken to assess the effect of the relaxant. As the changes noted were slight and were regarded as of no significance, the relaxant was discontinued after 74 records had been taken.

The electric convulsion shock was given with a Plexicon electroplexy unit, while a further tracing was recorded. Except for a short period during the application of the electrodes and the insertion of the Multitone mouth gag as described by Back (1952), which at the same time permits the maintenance of a good air-way, the lungs were inflated with oxygen from the beginning of the apnoea until adequate respirations returned.

Material

We recorded 214 E.C.G.s from 105 patients who received E.C.T., 57 of the patients being investigated on more than one occasion. In 14 records, in spite of the use of the relaxant, there was interference gross enough to make interpretation difficult or even impossible; this occurred mainly in the early cases, before it was definitely known how much suxamethonium was needed to ensure complete inertia. In 50 records there was slight interference, which did not seriously affect the reading of the tracing, whilst 150 were good.

There were 37 males and 68 females in the series, and their ages ranged from 16 to 78. Just over 50% of the female patients were in the age group 30-50, and almost twice as many were under 50 as over 50, whereas amongst the males the cases were almost equally divided between those under 50 and those over 50, with the majority also about equally divided between the 30-50 and 50-70 age groups (see Table).

Age Incidence

	Under 30	30-50	51-70	Over 70	Total
Male	4	15	16	2	37
Female .. .	10	35	19	4	68
Total .. .	14	50	35	6	105

Most of these patients had normal hearts, but in 10 a cardiac abnormality had been recognized clinically or was suspected from the appearance of the control E.C.G. Two men, aged 57 and 77, gave a past history of cardiac infarction and had abnormal E.C.G.s, one showing a right bundle-branch block pattern. In a woman aged 61 there was also a right bundle-branch block picture but no history of cardiac pain and no other electrocardiographic abnormality. In three women, aged 50, 55, and 66, the control E.C.G. suggested old posterior cardiac infarction. Two women, aged 34 and 58, had clinical evidence of mitral stenosis, although not of a severe degree. In a man aged 60 there was evidence of left ventricular hypertrophy, and complete heart block was found in the control record of a woman aged 31.

Results

Effect of Suxamethonium

In the first 74 records the effect of the suxamethonium was studied. The rate became faster in 41, slower in 13, and remained unchanged in 20; in no case was the change in rate marked. There was slight depression of the ST segment or flattening of the T wave in 5 cases, possibly due to temporary inadequate oxygenation immediately following diaphragmatic paralysis. There were no premature beats and no significant conduction changes.

Effect of the Shock

Rate.—In the control records the pulse rate was under 100 in 48% and under 130 in 87%, although a sinus tachycardia of 160 was encountered in 4 cases and of 170 in one case. A marked tachycardia developed within a few seconds of the shock being given. This usually lasted about 30 to 45 seconds, and in 65% of the cases the rate was over 130. In 37% it was between 140 and 160 and in 10% it was over 160, the most rapid rate recorded being 180. In nearly all instances the rate had returned to pre-convulsion figures within two minutes. In a few cases the sinus tachycardia was preceded by a sinus bradycardia lasting two to three

seconds. In nine cases a marked sinus bradycardia occurred shortly after the convulsive stage. In 17 cases there was no appreciable change in rate, and in several of these there appeared to be no convulsion at all—that is to say, the electrical stimulus had produced a stun or sub-convulsion.

Arrhythmias.—In 7 cases premature beats were present in the control, five being ventricular and two auricular. Amongst the 200 records which were clear enough for analysis, arrhythmias were encountered in 79 (39.5%), all being due to premature beats, except for one case of nodal rhythm. In 55 (27.5%) the arrhythmias were ventricular in origin, in 22 (11%) auricular, and in one case nodal. The ventricular premature beats were often multifocal and occurred singly, in groups of three or four, or at every alternate beat, coupling resulting in 19 cases (9.5%). Both auricular and ventricular premature beats were found in the same records in two cases. In a number of cases unusual waves occurred. At first sight they resembled those of a ventricular tachycardia occurring regularly at 150 a minute, but they were due to muscle contractions in patients who had had doses of suxamethonium insufficient to prevent muscular activity. In others in which the attenuation was greater, but still insufficient, a picture resembling an auricular tachycardia was produced. None of these abnormal waves was seen when the convulsion was completely attenuated or when the convulsive stage had passed. They occurred between 5 and 30 seconds after the shock was given.

Disturbance of Conduction.—In the one case of complete heart block in the control record premature ventricular beats and coupling developed during the convulsive stage. In only one case was the P-R interval abnormally lengthened, and then only temporarily, increasing from 0.16 sec. in the control to 0.24 sec. for four complexes. This occurred after a stun in a woman of 28; but on three subsequent occasions, shortly afterwards, when the shock was repeated in the same patient with a successfully modified convulsion, there was no disturbance of the P-R interval. In no case was prolongation of the QRS complex caused by the shock. In the two patients in whom there was a prolonged QRS complex in the control record it was not altered during the convulsion.

ST Depression.—Slight ST depression was present in the control records in 21 patients, in 16 of whom it was associated with tachycardia, while in 2 cases the presence of pathological Q waves suggested old infarction. Some degree of depression of the ST segment was found in 63 E.C.G.s recorded in 37 patients after the shock was given. In 42 records from 25 patients it was considered to be due to the Ta wave, secondary to tachycardia. In the other 21 from 12 patients the characteristics of the ST depression were such that it was judged to be ischaemic in origin. The age of these 12 patients ranged from 42 to 70, and in two the possibility of posterior cardiac infarction had been noted in the control curves.

T Waves.—As was to be expected, slight lowering of the T wave was often encountered with the development of tachycardia, but in 7 cases the waves were flattened, and in the case of a woman aged 40 they were inverted in two records.

U Waves.—In 91 records U waves became visible during the period of slowing following the cessation of the convulsive stage. They usually appeared when the rate had fallen below 100, and were often prominent even when they had been small or absent in the control. On no occasion was inversion of the U wave found.

Discussion

Anaesthesia and Relaxation

All the established muscle relaxants have been used to mitigate the fits which are produced during E.C.T.; but there are few anaesthetists who do not recognize the great contribution which has been made by the introduction of the ultra-short-acting group of relaxants, particularly when the frail and elderly patient is being treated. By the use of

these drugs complete relaxation can be ensured, if necessary throughout the whole period of stimulation, and yet rapid recovery can be expected. Because of this degree of relaxation we have obtained electrocardiographic tracings, free from interference, covering the period of treatment from beginning to end.

One of two relaxant drugs is now commonly employed; either suxamethonium chloride ("scoline," "anectine," succinylcholine chloride) or suxethonium bromide ("brevidil E"). Suxethonium has the advantage of a slightly shorter action (Wolfers, 1953), but as the degree of relaxation it produces is less reliable than that produced by suxamethonium, we chose to use suxamethonium throughout this investigation.

Suxamethonium appears to be a safe relaxant for E.C.T. provided adequate oxygenation is maintained throughout its short period of action. Adderley and Hamilton (1953) stated that some rise in blood pressure invariably occurred after a single dose of the drug, but considered this to be of little importance. Calvert and Morgan (1954), in a study of 57 patients during 200 consecutive convulsions, were unable to find any rise in blood pressure after administering the drug, and they thought that any rise that does occur is due to carbon dioxide accumulation and not to a direct pressor action of the drug. Using suxamethonium as a continuous drip, Green (1953) found that in most patients no rise in blood pressure occurs until at least 500 mg. of the drug has been administered, provided adequate ventilation is maintained.

Attempts have been made to use this drug alone to modify the convulsion, but the painful contractions which precede the relaxation and the unpleasant sensation of progressive paralysis make the procedure too unpleasant for the patient, as retrograde amnesia following the shock is never sufficient to cover this period. The relaxant drug is therefore always preceded by thiopentone. It is not sufficient to mix the two drugs together, as then the suxamethonium begins to take effect before unconsciousness occurs. The thiopentone is given slowly and in minimal doses, particularly in the elderly, so as to avoid undue lowering of the blood pressure.

In spite of the large doses of relaxant used, no very prolonged period of apnoea was recorded, 12 minutes being the longest.

Cardiovascular Effects

E.C.T. in the treatment of psychiatric patients has been practised for 15 years, and from the first it was felt that it might prove a severe strain on the cardiovascular system (Myerson, 1942). In spite of the frequent use of this form of treatment, however, fatalities involving the heart have only rarely been recorded. Ebaugh, Barnacle, and Neuburger (1943) report the death of a 57-year-old man from coronary thrombosis an hour and a half after the convulsion; he had already had twelve treatments, and, although a previous E.C.G. had been regarded as normal, extensive coronary disease and a recent thrombosis were found at necropsy. Kauntze and Parsons-Smith (1948), in 63 electric convulsions on 51 patients, found no evidence of any serious cardiovascular effects, but thought that coronary disease was a strong contraindication. Plice and Pfister (1950) believed that certain electrocardiographic abnormalities were caused by psychiatric disturbances, and described improvement in ST segments and T wave changes following E.C.T. Magendantz and Shortsleeve (1951) found that in many cases ST depression and T wave changes were due to anxiety and disappeared after rest and reassurance.

In our series ST and T wave changes were rarely present in the control records except in association with tachycardia, and even then they were slight. In the convulsive stage a marked auricular T wave associated with tachycardia occurred in 37 records (18.5%), but 21 records (10.5%) in 12 patients showed temporary ST depression which, adopting the criteria accepted by Wood *et al.* (1950), we regarded as ischaemic. Such a change can be due to anoxia from inadequate ventilation, but every effort was made to maintain adequate oxygenation, and in the six patients who had

more than one treatment the change was usually consistent. Furthermore, the ages of the 12 patients ranged from 42 to 70 years, with an average of 53; and, in two, changes suggesting coronary disease had been present in the control records. It was therefore concluded that the changes might possibly indicate latent coronary artery disease. It is, however, noteworthy that no ischaemic ST changes developed in the two patients who gave a history of cardiac infarction.

Lowering of the T wave was generally encountered only with considerable tachycardia, but an ischaemic cause was suggested by the inversion of T in Lead I in a woman of 40 in whom the control showed slight ST depression and a diphasic T in Leads I and II, for in this case the rate rose to no more than 120 a minute.

The frequency of U waves, which are thought to represent a process of repolarization of the interventricular septum (Zuckermann and Cabrera, 1947; Goldberger, 1953), is not considered to be of pathological significance, for they were upright in all cases; but it is interesting to note that they often became visible or accentuated in the stage of recovery following the convulsion. That they cannot be seen until the rate slows to less than 100 is of course due to the shortness of the T-P interval while tachycardia is present. Their increased prominence in many cases soon after the convulsion suggests a temporary change in the relative intraventricular pressures, for it has been shown that the U wave is influenced by changes which unilaterally alter the pressure on the septum (Zuckermann and Cabrera, 1947).

Anoxia was regarded by Kauntze and Parsons-Smith (1948) as the possible cause of the slight auriculo-ventricular conduction delay noted in half their cases and the intraventricular delay which occurred in 4%. In our series the P-R interval was abnormally prolonged in only one instance, and then after a sub-convulsion, and on no occasion did intraventricular delay result. The difference in these results can probably be accounted for by the greater ease with which we were able to inflate the lungs of our patients with oxygen during the convulsive stage.

Tachycardia was the principal effect of shock therapy, and this was always sinus in origin. In a few cases it was preceded by a sinus bradycardia for a few seconds, and in a few others bradycardia followed the convulsive stage; this was considered to be a vagal effect.

The absence of any change in rate was thought to be helpful in recognizing stuns, for their recognition is, of course, made more difficult by the use of large doses of muscle relaxants. In obvious stuns there is no change in rate, while only in a few cases with a definite convulsion was there no such disturbance.

The frequency of ectopic beats (39.5%) in our series is in contrast to that of Kauntze and Parsons-Smith, in which they occurred in only 8%. This is probably because in their series E.C.G.s could be taken only after the convulsive stage, during which the majority of the ectopic beats take place. Phillips (1954) has reported frequent ventricular extrasystoles following the administration of suxamethonium in the conscious patient, but only rarely when the relaxant was preceded by a sleep dose of a barbiturate. No premature beats were found after suxamethonium in our series of control records.

When two or more convulsions were studied in the same patient there was a relatively constant effect with regard to the presence and type of rhythm abnormality as well as to the degree of tachycardia which resulted. The rhythm changes, although frequent, were not marked, and in most cases were of short duration.

Conclusions

It seems probable that E.C.T. results in much less strain on the cardiovascular system than was originally anticipated. As in the majority of other recorded series, our cases have for the most part shown no evidence of any cardiac abnormality. The few that did show clinical or electrocardio-

graphic evidence of such abnormality suffered no ill effects from the convulsion. Nevertheless, if frequent premature beats can occur so readily in normal hearts, more serious arrhythmias which are potentially harmful might occur in diseased hearts. It is therefore suggested that quinidine or procainamide ("pronestyl") may prove of prophylactic value in such cases, and one of these should be readily available for intravenous injection should a serious arrhythmia occur. Severe coronary artery disease, and in particular recent infarction, and evidence of any considerable degree of heart failure should still be regarded as contraindications to the use of E.C.T. Should treatment be considered essential on psychiatric grounds, however, it is unlikely that there would be any serious outcome, provided the precautions were taken of using a short-acting muscle relaxant, of ensuring adequate oxygenation, and of preventing the development of serious arrhythmias by means of procainamide.

Summary

A series of 105 patients were submitted to 214 electric convulsions which had been modified by the intravenous injection of ultra-short-acting muscle relaxants. Electrocardiograms were taken before, during, and after the convulsive stage.

In 10 cases with clinical or electrocardiographic evidence of heart disease, no serious cardiovascular disturbance occurred.

A marked degree of sinus tachycardia was usual. Nodal rhythm developed in one case and premature beats were recorded in 39% of the cases.

In view of the frequency of premature beats, it is suggested that quinidine or procainamide may be used prophylactically in cases in which the onset of gross arrhythmia is expected or feared.

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Dr. J. A. MACFARLANE, dean of the Faculty of Medicine at the University of Toronto, has some remarks to make in his report on the 1953-4 session about the teaching problems raised by new trends in methods of investigation and treatment. "This school," he writes, "has tried to hold an even balance between the constantly changing and more complicated methods of laboratory investigation and the system of bedside teaching and theatre clinics, with emphasis on the careful taking of history and painstaking physical examination. There are so many human ills that cannot be measured by any laboratory calculation. The student of medicine has much to gain from sound clinicians who still practise the art of medicine with a full knowledge that the techniques of university laboratories and their experts are immediately available when they are indicated."