USE OF SUCCINYLCHOLINE IN E.C.T. WITH PARTICULAR REFERENCE TO ITS EFFECT ON BLOOD PRESSURE

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In recent years it has been possible to apply electric convulsion therapy to a wider range of cases than previously, with the aid of curare-like substances to weaken the muscular spasms of the convulsion. For the specific requirements of E.C.T. the newly introduced short-acting group of muscle relaxants is particularly appropriate. This paper deals with the practical problems that arise during this type of treatment and the methods of dealing with them. Certain theoretical problems are also discussed.

The contraindications to convulsion therapy, in other-wise suitable patients, are usually classified into two groups: those due to the effects of the convulsion itself—for example, damage to bones, damage to tuberculous lesions in the lung—and those due to the strain on the cardiovascular system, particularly incipient heart failure and hypertension. Since depression, for which E.C.T. is usually given, becomes more common with increasing age, hypertension becomes the most frequent contraindication to treatment. There has been much discussion on this problem. Kraemer (1950) measured the blood pressure immediately before the shock, and 2, 5, 10, 30, and 50 minutes afterwards. The average rise of pressure was 40/10 mm. Within 10 minutes it had returned to normal. He concluded that moderate hypertension was not a contraindication to E.C.T. In some preliminary measurements we found that the B.P. is extremely variable, undergoing a number of phasic changes during different stages of the convulsion and immediately afterwards.

Eyman and Morris (1950) discussed fatalities associated with E.C.T., and emphasized the risks of cardiac abnormality. They recommend that an E.C.G. should be taken before treatment is given wherever cardiac involvement is known or suspected. On the other hand, Piette (1950), who agrees that most of the fatalities are due to cardiac failure, thought that in such cases there may often be no clinical or E.C.G. abnormality in the cardiovascular apparatus. This is in agreement with Bankhead, Torrens, and Harris (1950), who state that cardiac reactions are due to overactivity of the vagus, and are of the opinion that they can be eliminated by premedication with atropine. There is no doubt that E.C.T. produces a rise in blood pressure, although this is of fairly short duration. In practice very few fatalities have occurred, but the possibility cannot be excluded that this is partly because of the caution exercised by physicians in the selection of cases for treatment.

The use of relaxants in E.C.T. has been recommended on the grounds that it reduces the strain on the heart produced by the convulsion, so that the presence of hypertension can be regarded as an indication for their use. It was therefore decided to investigate the changes

in blood pressure which occur in E.C.T. when relaxants are used. So far as we are aware, this has not previously been studied; the paper by Davies and Spencer Paterson (1952) dealt with the hypertensive effect of electro-narcosis. Piette (1950) stated that curare does not suppress the rise in blood pressure due to E.C.T., but if it is used with sodium thiopentone, atropine, and oxygen the variations in arterial pressure which normally appear are entirely avoided. Since the shorter-acting relaxants can be used not only to "soften" the convulsion but to eliminate it completely, without at the same time producing respiratory difficulties afterwards, it would seem that they are eminently suitable for this purpose. This investigation is therefore confined to the use of succinylcholine ("scoline").

No attempt was made to select patients, who came from our own wards. They were all women, chiefly elderly, feeble, and hypertensive, with a few younger healthy ones.

Methods

The procedure was as follows. Blood pressures were taken with an aneroid-type sphygmomanometer, because it is speedy and convenient in use. They were taken immediately before the injection of sodium thiopentone, one minute after that injection, again after the injection of succinylcholine had become effective, and, lastly, immediately after the convulsion was over. The moment selected for taking the B.P. after the injection of succinylcholine was when the fibrillation produced by the drug had ceased, and therefore when paralysis was complete. Preliminary trials showed that 0.2 g. of sodium thiopentone was enough to produce unconsciousness in most of our patients, and this amount was always used. It is not often that more would be required, except for very big patients. The recommended dose for succinylcholine is 1.2 ml. of a 5% solution, but we found that 1.5 ml. produced complete relaxation in our patients and did not give rise to any difficulties. More could be given, and we have done so, but, again, the larger dose would in general be required for only very muscular patients. The lungs were inflated two or three times with oxygen containing 5% carbon dioxide, just before a shock of 30 joules was given.

Results

The results of these preliminary trials showed the expected drop of blood pressure after sodium thiopentone medication, but an unexpected rise was almost invariably found after the injection of succinylcholine. This rise was not further increased by the convulsion. The accompanying Table gives the results in 12 consecutive cases. The rise in B.P. demonstrated in the Table is statistically very highly significant. A similar rise after the injection of succinyl-

Blood Pressure in Patients Given E.C.T. After Sodium Thiopentone and Succinylcholine (Recorded to Nearest 5 mm.)

At Beginning	After Thiopentone	After Succinylcholine	After Fit
160/95	130/95	160/110	170/90
150/90	120/80	120/80	140/80*
160/90	145/85	185/120	180/100
160/80	150/75	190/130	160/100
140/80	130/75	150/100	180/100
140/90	110/75	170/105	160/90
140/80	110/70	140/90	150/90
125/90	120/80	140/90	100/60*
175/105	140/90	220/160	200/110
150/100	150/80	195/100	180/100
140/90	130/80	200/150	190/110
160/90	135/80	180/160	200/100

Mean B.P. after sodium thiopentone 130.8/80.4 mm.
Mean B.P. after succinylcholine 170.8/116.2 mm.
Difference 40.0/35.8 mm. $\pm$ S.D. 22.6/26.5 mm.
Number of cases = 12.

$t = 6.2/4.7$. P is $< 0.001/ < 0.001$.

* Part of the succinylcholine leaked out of the vein in these cases.

choline was found in each of the subsequent experiments. The overall effect of this substance—that is, the change from the initial B.P.—is, of course, not so great, but it is still highly significant statistically.

It is possible that this increase of B.P. might be due to the delayed effects of the sodium thiopentone. A control series was therefore investigated in which succinylcholine was replaced by the same volume of sterile water, and the B.P. taken after the same interval. Subsequently, the normal procedure was completed. It was found that the injection of sterile water had no significant effect on the blood pressure. The results were as follows:

No. of cases		10
Mean B.P. after sodium thiopentone		122.3/75.4 mm.
" " sterile water		121.8/74.5 mm.
Difference:	-0.5/-0.9 mm. $\pm$ S.D. 7.8/9.1 mm.	

This proves that the rise must be due to the succinylcholine.

This rise in B.P. produced by succinylcholine is not very great, but if the relaxant is to be used for borderline cases in which any strain on the heart might be dangerous it is a matter of practical importance. It was decided to investigate the possibilities of ganglion-blocking agents in preventing this rise. The two substances tested were tetraethylammonium bromide (T.E.A.B.) and hexamethonium iodide ("hexathide").

Preliminary trials showed that both ganglion-blocking drugs achieved their maximum effects in two minutes, and that the optimum dose of hexamethonium iodide was 2 ml. of a 2% solution. The new procedure was as follows. After the first B.P. reading 2 ml. of hexamethonium iodide was injected, followed immediately, through the same needle, by the normal dose of sodium thiopentone. The B.P. was taken one minute after this, the rest of the procedure being identical with that in the first experiment. The results of this new procedure were satisfactory, and demonstrated that this dose of hexamethonium iodide did not produce a profound fall of B.P. and was enough to prevent the B.P. rising above the normal for the patient even after the convulsion. The results were:

No. of cases		10
Mean B.P. at the beginning		171.0/96.0 mm.
" " after fit (preceded by hexamethonium iodide 2 ml., thiopentone, and succinylcholine)		139.0/88.5 mm.
Difference:	-32.0/-7.5 $\pm$ S.D. 27.3/21.2 mm.	

This procedure was repeated, using T.E.A.B. instead of hexamethonium iodide. It was found that 1 ml. of a 10% solution was just enough for most cases. The results were:

No. of cases		9
Mean B.P. at the beginning		159.4/91.1 mm.
" " after fit, etc.		152.8/92.8 mm.
Difference:	-6.6/+1.7 $\pm$ S.D. 29.4/22.0 mm.	

The results with 2 ml. are but little more effective for the average case:

No. of cases		10
Mean B.P. at the beginning		184.5/93.5 mm.
" " after fit, etc.		168.0/92.5 mm.
Difference:	-16.5/-1.0 $\pm$ S.D. 31.4/11.73 mm.	

Discussion

The most important of our observations is the undoubted rise in B.P. following an adequate relaxant dose of succinylcholine. This has previously not been described in the literature; in fact, succinylcholine in clinical doses has been stated to have no effect on the arterial pressure. Experiments on animals have shown that a dose of 25 times the normal, or even higher, is required to produce any increase in the B.P. The difference between this and the results found in our patients is probably a species difference. Since the hypertensive effect of succinylcholine is not eliminated by blocking the autonomic ganglia, either it must be due to an interference with the action of the blocking agent or it acts peripheral to the ganglion. If it be the former, then succinylcholine must have a reaction similar to the "nicotinic" action of acetylcholine. It is evident that the ques-

tion can be settled only by experiment, preferably on human tissue. This is outside the field of this paper, which is restricted to purely clinical matters.

Smaller doses of succinylcholine would have much less effect on the B.P., but then the specific value of this drug would be lost. It can be used to produce a paralysis so complete that no muscular activity can be seen at all during the "convulsion." This eliminates all strain on the cardiovascular system from that particular aspect—which is confirmed by the fact that the patient remains quite pink throughout. Furthermore, recovery from a full dose is just as rapid as from a smaller dose, unlike the longer-acting relaxants. Previous reports have indicated that the latter do not increase the B.P. This would be a contraindication to the use of succinylcholine were it not for the fact that the convulsion itself produces such a rise. If a ganglion block be used to deal with this, it can be used also to cover the hypertensive effect of the succinylcholine.

It was noticed on two or three occasions that after the injection of succinylcholine the pulse became irregular, apparently owing to extrasystoles. It is unlikely that such irregularities are common, and, in any case, they were never observed when the autonomic ganglia were blocked.

We have the impression that the effect of blocking the autonomic ganglia is greater in those patients with the higher blood pressures. This is probably true, but would require a special investigation, with careful standardization of many factors, to test it adequately.

Practical Points

The statistics given are based on a limited number of cases dealt with by the technique described. This, however, is unnecessarily elaborate for routine work, and normally all that would be required would be the following:

1. We consider that an injection of atropine should always be given, to reduce salivation and excessive bronchial secretion. When a relaxant is to be used it is important that the patient should be placed in a comfortable position, to prevent strain on the ligaments when not protected by the tone of the muscles.

2. Sodium thiopentone and succinylcholine may be mixed in the one syringe, provided this be done immediately before injection. This enables a one-syringe technique to be used when no ganglion-blocking agent is given.

3. The ganglion-blocking agent should be given before the mixture of thiopentone and succinylcholine, as the former takes slightly longer to produce its full effect.

4. If a few breaths of oxygen be given before the shock the patient stays pink throughout. In our experience with succinylcholine, running into several hundred administrations, we have never observed prolonged apnoea, which, we think, may be due to an unsuitable technique.

5. It has been our practice to press upon the epigastrium just before the current is passed, to prevent the patient waking with a stomach distended by the oxygen used for inflation.

6. *The Convulsion.*—With complete relaxation it is difficult to determine whether an adequate convulsive dose has been given. We have employed two methods for this purpose: (a) By noting the autonomic component of the cerebral discharge which constitutes the fit; the simplest observation is to look for dilatation of the pupils, and, particularly, injection of the conjunctivae. (b) As this method is not always accurate with ganglion-blocking agents we have devised a specific manoeuvre to demonstrate the presence of the fit. Immediately before succinylcholine is injected a tourniquet or a sphygmomanometer cuff is fixed round the opposite arm. If this be kept tight enough to compress the artery until the current is passed the effects of the shock will be observed in that arm only. Thus the patient may be seen lying absolutely motionless apart from a slightly modified clonic fit in the blocked arm. By this means one is never in doubt about the effectiveness of the current.

Summary

Succinylcholine is a safe relaxant for E.C.T.

It can be used to abolish the convulsion completely ; even with the doses necessary to do this the patient's recovery from the fit is always rapid.

Succinylcholine produces a slight rise of blood pressure which is generally unimportant. If necessary, this can be controlled by blocking the autonomic ganglia.

When complete muscular relaxation is advisable succinylcholine can be administered with safety without any elaborate system of dosage. In such cases the presence of a fit can be detected by the simple manoeuvre described.

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CANICOLA FEVER

A HUMAN CASE IN NORTHERN IRELAND

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In 1931 Klarenbeek and Schüffner (1933) isolated *Leptospira canicola* from the urine of a dog. This discovery was soon followed by the recognition of *L. canicola* infections in man (Dhont *et al.*, 1934). Baber and Stuart (1946) reported the first human infection in England ; Joe and Sangster (1951) published the first cases in Scotland, although Stuart (1938), in a survey of Glasgow tripe-workers, had found agglutinins in low titre to *L. canicola* in the serum of a woman who gave no history of illness. In the four-year period 1947-50 70 cases were diagnosed in England and Wales (Broom, 1951). Figures given by Alston (1951) show that 25 cases occurred in 1949 and 33 in 1950.

Broom (1951), in a review of leptospirosis in England and Wales, drew attention to the fact that no human case of canicola fever had yet been reported from any part of Ireland, although his survey of the incidence of the disease in Dublin dogs had shown the infection rate in that city to be as high as in England.

The case recorded here is, we believe, the first serologically proved human infection with *L. canicola* reported from Ireland.

Case Report

A muscular and well-nourished man aged 36 was admitted to a surgical unit of the Belfast City Hospital on February 1, 1952. Eight days before admission he complained of feverishness and shivering attacks of abrupt onset. He was forced to give up work six days before admission, and he took to bed one day later. He then developed pains in the legs, lumbar regions, and right renal angle ; these were severe and disturbed sleep. Other symptoms were colicky pains in the right hypochondrium and epigastrium, loss of appetite, vomiting, tiredness, photophobia, and very severe frontal headache. Frequency of micturition, dysuria, and oliguria caused him to summon his medical attendant, who visited him on January 29 and found his temperature to be 102° F. (38.9° C.) and the urine to contain a heavy cloud of albumin. A tentative diagnosis of acute pyelitis was made and treatment by oral sulphatriad instituted. The pyrexia promptly subsided, but nausea and vomiting became troublesome, and admission to hospital was arranged.

On admission his temperature was 98° F. (36.7° C.), pulse 104, and respirations 22. Clouding of consciousness was considerable ; there was no neck rigidity, and Kernig's sign was negative. The face was flushed and the conjunctivae were markedly congested and suffused. Jaundice was absent. A patchy erythema was noted on the chest, also labial herpes. The tongue was coated. Slight tenderness was elicited over the right upper abdomen, the liver and spleen were not palpable, and the renal angles were free. The urine was acid and contained a trace of albumin with scanty red blood cells but no pus or organisms. On the day after admission the temperature rose to 99.2° F. (37.3° C.), but afterwards remained subnormal.

The patient was seen at this stage by one of us (A. C. H.), and the possibility of leptospiral infection was discussed. He was transferred to a medical unit for further investigation, although clinical recovery was rapid and uneventful. Discovery of a positive leptospiral agglutination prompted an exhaustive inquiry into the history of the case, and it was found that the patient's dog had sickened and died after a few days' illness, during which the patient had tended the animal and handled it a great deal. The patient first felt unwell about three days subsequent to the dog's death. He worked as a labourer in a bakery which was infested by rats and required periodical deratting. One such campaign had occurred about a week before the present illness.

The patient insisted on being discharged on February 11, before an effective penicillin course could be completed. Shortly after leaving hospital the muscular pains reappeared and a pustular rash developed on his face. He returned to hospital on his doctor's advice two weeks after his initial discharge. On this occasion his general condition seemed satisfactory, and the limb pains rapidly subsided. He was given a penicillin course (2,000,000 units daily, intramuscularly, for 12 days) and the laboratory tests were repeated. The leptospiral agglutinins of the other members of the household and of three fellow workers were examined.

Agglutination Tests

The technique of the agglutination tests was Broom's (1948) modification of that of Schüffner and Mochtar (1927). The first specimen of blood, taken on the 12th day of illness, agglutinated *L. icterohaemorrhagiae* and *L. canicola*, both to titres of 1 in 300. (In the early stages of leptospirosis equal or nearly equal titres are common.) Subsequent specimens, taken over a period of weeks, gave agglutinins which showed a falling away of the heterologous titre, while the homologous titre remained high (see Table I).

It will be seen that the second specimen of blood serum (taken on the 19th day of illness) gave agglutination in higher titre for *L. canicola* ; this serum was sent to Dr. J. C.