A CRITICAL REVIEW

THE TREATMENT OF MENTAL DISORDERS BY INDUCED CONVULSIONS

BY

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HISTORICAL INTRODUCTION

The concept of the treatment of mental disorders by artificially induced convulsions owes its origin to the combination of two previously known facts. One of these was that some substances were able in toxic doses to bring about convulsions in man, without necessarily causing death, and that controlled convulsions could be produced by them in animals without apparent harm. The other was the observation that the development of spontaneous convulsions in persons suffering from schizophrenic psychoses had been followed in some cases by a rapid remission in the mental symptoms.

Although the validity of the supposed antagonism between epileptic and schizophrenic states has been recently much questioned, it was the attempt to utilize this antagonism for therapeutic purposes that formed the theoretical foundation of convulsion-therapy. Müller in 1930 had summarized the evidence for this hypothesis, and it was Nyiró who, in 1932, first attempted to make use of it by transfusing schizophrenic patients with the blood of epileptics. The lack of therapeutic success of this method suggested to Meduna the idea of actually reproducing the epileptic convulsions in his patients. In 1933, therefore, after preliminary experiments on animals had established that there was no gross damage to the nervous system after convulsions induced by toxic doses, Meduna gave 20 per cent. solutions of camphor to a group of schizophrenics, by the intramuscular route in gradually increasing doses, until convulsions were produced. Although in many cases the psychoses of these patients were of long duration, the results were sufficiently encouraging to warrant further trials. The very considerable technical difficulties involved in the use of camphor have led all but a few workers to abandon it as a convulsant, and Meduna’s attention was early directed to the suitability of pentamethylenetetrazol, with which convulsions had been readily produced in animals. This drug possessed the convulsant properties of camphor with the advantages of solubility and suitability for intravenous use, together with rapid excretion and few toxic effects, and was used in 1933 in his next series of cases.

As with many advances in medical science, the idea of using camphor convulsions in treatment was not entirely a new one, and Glesinger, Havas, and...
Meduna (1938) have collected some references to its use in early psychiatric literature. Leopold v. Auenbrugger, in 1764, advised in cases of Mania Virorum that a mixture containing camphor should be taken every two hours day and night. In 1781 William Oliver of London (quoted by Diethelm, 1939) recorded how a case of mania improved following convulsions brought about by the administration of large amounts of camphor given to induce rest; while A. Weickhardt in his "Medizinisches Praktisches Handbuch" of 1798 advises that in cases of lunacy, camphor should be pushed to the point of producing vertigo and epileptic fits, after which point is reached, he says, the condition will usually clear up. G. Szekeres of Olmutz, in 1851, quotes Pauliczky as recommending that, in cases of insanity, camphor should be given in doses increasing by 5 grains until 60 grains are given daily, and that this dosage should be continued until fits appear. After the fits, he says, the patients will become lucid and commence to recover. References to the beneficial effects of convulsions on mental disorders also occur in the French literature of the eighteenth century, and it is clear that their therapeutic use has only now been revived after a lapse of almost a century.

If, in retrospect, the working hypothesis which led Meduna to develop this mode of treatment may seem debatable, the results recorded in the earlier publications commanded attention and led to a rapid extension of clinical trials. The Hungarian publications were soon followed in 1934 by others from Germany and Switzerland. It is probable, however, that other factors than those of distance and of language delayed further adoption of the method, especially in the English-speaking countries. The drastic nature of the treatment and its possible conflict with the traditional caution of English medicine produced a justifiable hesitancy to submit it to clinical trial. The attention of psychiatrists was also focused at that time on the claims of prolonged narcosis and of insulin therapy in schizophrenia, the latter being in use in England and America at the end of 1936. It was the congress on shock therapy at Münsingen in May 1937, the reports of which are now available in English (Katzenelbogen, 1938), that drew attention to the necessity for further serious trial, and shortly after this congress the first case-reports appeared in English from both sides of the Atlantic. Since then there has been a period of extensive clinical trial all over the world, and early enthusiasm has given place to a more seasoned evaluation of the uses and dangers of the method. The subject of convulsion-therapy has been under discussion at a number of conferences, such as that of the American Psychiatric Association (in 1938) and of the Royal Medico-Psychological Association in 1938, and a number of reviews have appeared (Thumm, 1938; Harris, 1938; Rees-Thomas and Wilson, 1938) which have allowed of some expression of opinion. These, with others, have been of considerable assistance to the writer in ascertaining current views as to the value of the method.

METHODS AND VARIATIONS—COMPLICATIONS

Technique.—Although there have been a great number of minor variations, the methods in use at most centres do not differ widely from the original technique of Meduna, which has been described too often for inclusion here, and is given in detail
in the Report of the Board of Control (Rees-Thomas and Wilson, 1938). Only the more striking variants will therefore be discussed. Some of the practical details will be referred to later in the section on the prevention of complications, while the psychotherapeutic aspects of treatment will also be left to a later section.

The majority of workers employ the buffered 10 per cent. solution and the usual initial dose is 5 c.c., to be repeated one minute later if no convulsion occurs. Dean (1938) allows for the slight tolerance which is usually seen by increasing the dose by 0.5 c.c. at every third injection, but the strength and duration of the fit is probably a better guide to future dosage. The tolerance developed to cardiazol is in contrast to the sensitization described as occurring with triazol 156, but it seems likely that the variations in the minimum convulsant-dose vary as much with the individual patient as with the convulant used. Opinions as to the maximum safe dose vary a good deal. Kennedy (1939) has shown that the response of monkeys to intravenous injections of cardiazol is very closely similar to that of man when doses are given in proportion to the body weight. When a dose equivalent to 14 c.c. in a man of average weight was given to these animals, a severe status epilepticus developed, though the animals eventually recovered. Although the experiments of Ligterink (1937) indicate that the fatal dose is probably about 30 c.c., considerably more has been given in the course of treatment without ill effect, such as the 46 c.c. of Meduna (1938). Rees-Thomas and Wilson suggest that 16 c.c. should be the maximum single dose, to be repeated once, a minute later, if no convulsion ensues. The usual practice is to give the injections three times a week.

In an attempt to reduce the dose necessary to produce a convulsion, by bringing about a metabolic state which favours convulsions, Friedman (1937) introduced the method of alkalization and hydration. This consists in giving a minimum fluid intake of 2 litres per day, together with a high alkaline ash diet and sufficient alkali by mouth to keep the urine constantly blue to litmus. The careful studies of Dean (1938) show that although patients in the alkaline-hydrated state may show muscular hyperirritability, there is little significant effect on the dosage of cardiazol, while the diet is very distasteful to the patient and may cause a loss of weight.

The majority of patients, while recalling nothing of the actual convulsion, retain at some period of the treatment a vague feeling that it has been an unpleasant experience, and this may cause a considerable anxiety and dread of subsequent injections. The patient may be spared much of this apprehension if care is taken that he does not see other patients having treatment and that he is not kept in suspense by unnecessary preliminaries to the injection itself. There is no doubt that this complication is less frequent if care is taken to avoid giving subconvulsant doses, which produce acute fear-states that the patient can actually remember. The method of treatment in a series of separate rooms has the advantage that the patient need not know about the injection until it is actually about to be given. Although the use of barbiturates is precluded because of their inhibiting effect on the convulsions, hyoscine has no such effect, and used alone (Kennedy, 1937; Cohen, 1938) or with morphia (Cook, 1938) assists materially in causing the patients to await the injection calmly and to forget the period immediately preceding it. Cohen has observed that hyoscine even somewhat increases the tendency to convulsions, allowing of a slight reduction in dose. The elimination of this dread of the treatment is one of the advantages of the "summation" treatment of Georgi (1937), in which the convulsions are induced when the patient is in early insulina coma.

Use of Convulsants other than Cardiazol.—One of the difficulties encountered by all the workers with cardiazol is that many catatonic patients with general vascular hypoplasia have very poor veins. Further, owing to the rather high pressure at which the solution is injected, thrombosis due to small paravenous leakages is fairly common, even if it has been minimized in reporting results. Cardiazol when given intramuscularly, is rather uncertain in its action and often causes a period of restless anxiety before the onset of the fit, due to its slow absorption.
Behrens, Dinkler, and Woenckhaus (1937) had shown that triazol 156 could be used to induce fits in predisposed subjects, and Walk and Mayer-Gross (1938) applied it to convulsion-therapy. They found that the 5 per cent. solution had no sclerotic action on the veins when given intravenously, though this had been since questioned (Uebler, 1939), and that it was absorbed sufficiently by the intramuscular route for this method to be practicable. It also has the advantage that less than 2 c.c. of the solution is usually necessary to produce a convulsion. Walk and Mayer-Gross (1938) found that the intramuscular dose was one and one-half to two times the intravenous dose, which is rather less than the proportion necessary for cardiazol. Braunmühl (1938) emphasizes the importance of accurate dosage and has determined a constant for its calculation from the body-weight. The average commencing dose is about 1·4 c.c. With intravenous triazol the period of induction of the fit is more prolonged and it is not always easy to be sure whether a complete convulsion will occur after the injection. Secondary convulsions are common and in some cases multiple fits occur. These are not necessarily harmful and it has been suggested that they should be induced deliberately; in any case, they can usually be stopped by injections of phenobarbitone. It is probable that triazol is eliminated more slowly from the body than cardiazol and great caution has to be taken in giving supplementary doses when no convulsion has occurred after the first injection, as accumulation of the drug may cause delayed multiple convulsions. The margin of safety is clearly less than with cardiazol and a second dose should be of only one-third of the original quantity.

Vomiting is a common complication after triazol convulsions, but it is easily prevented by premedication with atropine. When triazol is given intramuscularly, the time relations of the convulsive phenomenon are greatly lengthened, and Walk and Mayer-Gross have shown that, when it is dissected in this way, there are marked individual differences in the pattern of reaction. In some cases prolonged twilight-states occur, and these seem to be equal in therapeutic effect to the convulsions. The amnesia after triazol seems always to be greater than with cardiazol, and may occur even when a subconvulsive dose is given. It is for this reason, probably, that there is less fear of the injections with triazol, and it is more suitable for apprehensive patients. Braunmühl is of opinion that triazol gives better results with long-standing cases than cardiazol, which he prefers for recent cases, and that it is also more suitable for combined therapy with insulin than cardiazol.

A number of other substances have been suggested or used as therapeutic convulsants. Advantages are claimed for picrotoxin, suggested by Burn (1939) and used clinically by Low, Blaurock, Sachs, Wade, and Ross (1939). These workers found that there was an even longer interval between the injection and the convulsions than with triazol, and that multiple fits were common, but could be prevented by an intramuscular injection of seconal after the first convulsion. They report that there was practically no fear in their cases, and patients who had had cardiazol as well, preferred picrotoxin as it caused less unpleasant sensations. The use of monobrom camphor, which has been used extensively in animal experiments and does not appear to have toxic effects, such as are seen with thujone, was advocated by Wortis, Coombs and Pike (1931), but no clinical reports have appeared.

A number of Italian workers have obtained satisfactory results with 5 and 10 per cent. solutions of ammonium chloride (Bertolani, 1939; Maffa, 1939; Baraldi, 1939). No untoward complications have been recorded and the reduction in cost makes this drug seem very attractive.

Much attention has also been paid by Italian workers to the possibility of producing therapeutic convulsions by means of electric shocks. Cerletti (1939), after numerous experiments with dogs, has, with Bini, developed a method by which the current is applied by means of scalp electrodes. Their apparatus consists of two circuits, one of which is used to measure the resistance offered by the patient's head, in order to determine the current required, while the other is used to carry the shock itself. In a majority of cases an intensity of 150 volts with an alternating current of
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comparatively low quantity is sufficient to bring about a convulsion. Kalinowsky (1939) has pointed out that the convulsive threshold is lowest if the electrodes are applied over the area 6 α β of Foerster. The great advantage of this method appears to lie in the absence of unpleasant sensations in the patient. If a subconvulsive potential is applied, a petit mal reaction is obtained of which the patient has no memory. No fatality or case of burning has yet been recorded, and the surprisingly low intensities used suggest that the method is safer than might at first be thought. The development of this method is clearly of great theoretical importance, as, if the therapeutic effects are in every way similar to those of chemically induced convulsions, the effect of the convulsant agent per se can be eliminated from consideration.

Combined therapy with insulin has attained considerable popularity and the modification classed by Küppers as "summation" treatment, in which the convulsions are induced usually an hour and a half after the administration of a coma dose of insulin, is the most popular. The technique of Georgi and Strauss (1937) is most usually employed, and it is generally believed that the greatest benefit results if the cardiazol is given from the commencement, as soon as the insulin dose is established. The advantages of this method have been summarized by Russell (1938), who stresses especially the absence of fear in the patients and the fact that only small doses of cardiazol are necessary to produce fits, if it is given at the "turning-point" described by Georgi. Vomiting is a rather troublesome complication after fits induced at this period, but Russell says that this complication can usually be prevented if the stomach is emptied before the treatment is commenced and if atropin is given before the injection. Larkin (1938) recommends that a small quantity of glucose be given intravenously after the cardiazol, to prevent any possible collapse after the convulsion.

Indications for Convulsion-Therapy in Schizophrenia

Unfortunately there are no data available in which the case-material is classified into types, and all that can be given on this subject is a statement of general opinion as expressed in the conferences before mentioned and in the impressions of the different writers. There seems to be general agreement that, of the schizophrenic cases, those with catatonic stupor react best of all to convulsions, just as early paranoid cases react best to insulin. A special group of schizophrenics which reacts exceptionally well includes those having depressive symptoms. Cases of dementia simplex are generally agreed to react poorly to either method, and cases of paraphrenia occurring at the upper schizophrenic age-group appear to do little better. It is to be remembered, however, that these are the least prognostically favourable groups from the point of view of spontaneous remission. It might be fair to say that the prognosis of a given case under shock-therapy varies with its prognosis for spontaneous remission, but that the shock treatment affords an increased possibility of early remission. In choosing which method is to be employed, convulsion-treatment should be considered where the manifestations of the disease are essentially psychomotor or affective, and insulin-therapy where the disorder is predominantly intrapsychic.

Convulsion-Therapy in conditions other than Schizophrenia

The range of mental reaction-states which are benefited by convulsion-therapy does not appear to be limited to schizophrenia. Meduna has pointed out that there is little prospect of success where there is a poor heredity in a case
of schizophrenia, but that the outlook is best where the illness is the result of adverse circumstances: i.e. when it is reactive rather than endogenous. It is thus of interest to find that other states which may be in even greater part reactive have been found to respond favourably to convulsion-therapy. Favourable results have been reported in manic-depressive psychosis, in cases of involutional depression, and in the small number of cases of severe hysteria which have so far been published the effects reported have been very striking indeed.

Cook and Ogden (1938) were impressed with the favourable results in cases of schizophrenia which showed depressive features, and have published the results in a small series of cases of affective psychosis. It was noteworthy that in their cases the change in mood occurred after only a few injections and that a full course was not necessary. Similar results have been recorded by Goldstein and his co-workers (1938), Low and his co-workers (1938), Bennett (1938), Webster (1938), and Wyllie (1938), while Verstraeten (1938) has had favourable results with cases of involutional depression. The general impression at the moment is that convulsion-therapy is unlikely to have a specific effect on these psychoses, but that it is able sometimes to determine a favourable change of mood in cases where such a change may be expected to occur sooner or later. It is felt that in the present state of our knowledge the indiscriminate use of convulsions in affective psychoses is unjustified, even though the risks involved are not very great, and that the use of this method should be reserved for cases in which effects are likely to be permanent. Such circumstances would occur if a case showing no deterioration was lasting much longer than anticipated, or if the patient, by reason of excitement or agitation, was becoming exhausted. Other indications would be the occurrence of severe depressive stupor which interferes with nutrition or the occurrence of repeated attempts at suicide. The case of involutional depression is rather different. Although recorded material is as yet rather scanty, the opinion is gaining ground that the prognosis after convulsion-therapy in this condition is distinctly better than its prognosis with conservative therapy, and that a certain amount of risk is here justified. The effect of treatment seems to be upon the affective element of these psychoses.

Harris and Birnie (1938) have shown the value of convulsion-therapy in cases of stupor of all types, and have pointed out that the outlook in depressive stupor is always potentially good, even when the condition has been present for a long time, as there is here no process of deterioration which causes the patient's chances to become less as time passes by. In such cases Berrington has found the use of intravenous sodium amytal, according to the technique of Bleckwenn (1931) a valuable means of temporarily reviving the patient in order to assess the degree of deterioration and thought-disorder. Harris and Birnie (1938) observe that stuporose patients who show a good transient awakening with amytal are likely to respond to convulsion-therapy. Apart from the production of complete remissions it is felt that the use of convulsions is often justifiable if it is able, as it so often is, to end the stupor, with its attendant nutritional and nursing difficulties. Even if the patient cannot be discharged from the
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institutions afterwards, as the result of the treatment he often becomes a more useful and stable inhabitant of it.

It may perhaps be more helpful to regard convulsion-therapy not as a specific remedy for a single type of psychosomatic disorder, but rather as acting on a mental symptom-complex which is common to most of the conditions which it can affect favourably. The exact features of this symptom-complex must vary according to its setting, but inhibition and a depressive affect are certainly two of the features prominent in cases which benefit from convulsion-therapy. Thought-disorder, on the other hand, seems rarely to be improved except in so far as it is a consequence of inhibition. Where the patient’s reaction-form as a whole is a composite one, the degree of its recovery may depend on the amount of that component in its make-up which is favourably affected by cardiazol therapy.

The literature contains references to a small number of cases of gross hysteria which have been treated with cardiazol, and Low and Verstraten, Cook and Ogden (1938), and Read and his co-workers (1938) all record successful results. The writer feels that there is room for further investigation on these lines in cases of degenerative hysteria without epilepsy which have become inaccessible to psychotherapy and other measures.

Complications of Convulsion-Therapy and their prevention

It is unfortunate that with the exception of Meduna’s reports, the earlier papers on convulsion-therapy, in their enthusiasm for the method, gave little if any prominence to such complications as they observed. Later publications have not been entirely satisfactory in this respect; Ross (1939), for instance, in the report on 1,500 cases treated in the New York State Hospitals, records only complications which proved fatal. Apart from the results of an enquiry into the incidence of the more serious complications in the Dutch hospitals given by Pameijer (1938), there is little material from which to form a reliable estimate of their frequency. It is clearly impossible to avoid complications with a method which produces such violent effects on the organism. In visits to hospitals in Europe and in the United States the writer has had the opportunity of discussing the subject with many workers. The general opinion is that, while various non-fatal complications are very common indeed, they are mainly of a preventable kind. Their number tends to diminish as the practical experience of the hospital staffs increases.

Immediate Complications.—Minor complications occur mainly at the time of the actual convulsions. Venous thrombosis, while less frequent since the use of the 20 per cent. cardiazol solution has been abandoned, is a difficulty which is frequently minimized, but is not to be forgotten if the incidence of pulmonary abscess is to be lowered, as this is presumably due usually to the mobilization of thrombi from the site of injection. It is claimed (Walk and Mayer-Gross, 1938) that this complication is less common with triazol, though this is denied by Uebler (1939). The possibility of "speed-shock" has received prominence in view of the high speed at which the solution is usually injected.
but although the work of Hirschfeld, Hyman, and Wagner (1931) would indicate that with practically any substance injected rapidly the occurrence of anaphylactoid collapse is theoretically possible, there is as yet no recorded instance of this having occurred. Vomiting at the termination of the convulsion is not common with cardiazol alone, but is very frequent with triazol and in the insulin-cardiazol "summation" treatment of Georgi. In triazol treatment the giving of atropin and a small quantity of glucose before the convulsion will usually prevent this. While long apnoeic periods at the end of the clonic stage of the convulsion may give rise to anxiety, they do not appear to be dangerous if the airway is kept clear. Injection of lobeline has been suggested if artificial respiration is ineffective, but it must be remembered, as Draper and Whitehead (1939), have recently pointed out, that respiratory stimulants may have a depressant action where anoxæmia is extreme.

The most important immediate complications are the injuries which the patient may sustain as the result of the violence of the muscular contractions during the fits. It would seem that the actual pattern of the convulsion predisposes to certain injuries in cases where the bones or joints are vulnerable, and it is noteworthy that these injuries are not those found in idiopathic epilepsy. The very frequent dislocation of the jaw, which is regarded by many workers as inevitable in a small proportion of cases, is not often seen in epilepsy, and is clearly related to the sudden opening of the mouth which is so characteristic of the onset of the cardiazol convulsion. While it is readily reducible and usually causes little trouble, there is no doubt that its incidence is lower where the nurses have gained experience. Dislocation of the shoulder is a more serious but less frequent complication, though its frequency in Winkelman's (1938) series of cases led Rechtman and Winkelman (1939) to devise a special apparatus for the patients to wear in order to prevent it.

The most frequent major injuries reported in the literature are as follows:
Fracture of Neck of Femur: Pameijer 5, Walk 2, Jansen 2, Müller 2, Ross 1, Horn 1, Nyberg 1, Kerstens 1, Rees-Thomas and Wilson 1, Somers et al. 1; of Humerus: Pameijer 3, Wulfken 1, Kraus 1; of Scapula: Pameijer 3, Stahl 2; of Thoracic vertebrae: Stalker 1, Wespi 1, Polatin et al. 22, Palmer 5.
Dislocation of Shoulder: Winkelman 3, Somers et al. 2, Cohen 1, Pameijer "several," Harris and Birnie 1.

Meduna (quoted by Rees-Thomas and Wilson) in his reports of 1,244 cases treated in 29 American hospitals, records 27 fractures; while Pameijer found 15 in 1,200 cases. From this limited material the incidence of major fractures is 1.7 per cent., a matter of some seriousness when it is considered that fracture of the neck of the femur may be the most frequent of these. In two recorded cases (Ross, Walk, and Mayer-Gross) fracture of the femur contributed materially to a fatal issue.

Until very recently there were but two recorded cases of vertebral fracture, those of Wespi (1938) and Stalker (1938), both at the 6th thoracic level. In view of the high incidence of backache it seemed probable that minor non-bony injuries to the vertebral column might be common, but these were not thought likely to be dangerous. The work of Polatin, Friedman, Harris, and Horwitz,
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if confirmed, and little more confirmation is needed, may make us feel less
secure about such injuries. These workers investigated 51 cases radiologically
and found thoracic compression fractures in 22, or 43 per cent. The fractures
were not necessarily accompanied by backache, and the degree of injury bore
no relation to the amount of subjective complaint. It is evident that the mid-
thoracic vertebrae are the vulnerable points and that the anterior portions of the
vertebral bodies are crushed in the sudden anterior flexion at the onset of the
convulsion. It is clear that a large number of cases will have to be examined
and some postural means, such as that of Bennett and Fitzpatrick (1939),
found of avoiding this complication if the treatment is to be made safe. Con-
vulsions produced during spinal anaesthesia might prove a laborious, though
safe, solution of this problem. Palmer (1939) has also found a high proportion
of vertebral fractures in patients examined radiologically at the conclusion of
treatment. It is notable that in spite of these findings only the two first cases
recorded were seriously inconvenienced by the presence of the fractures, many
radiologically positive cases having no symptoms at all. If fractures are to be
prevented, it is clear that care must be taken to exclude cases which, by reason
of prolonged inactivity, of age or of inadequate nutrition, are vulnerable to
fractures on account of decalcification, and also to exclude the possibility of
predisposition to dislocation or of bone disease in cases which are chosen for
treatment. It is also necessary to keep the dosage of the convulsant down to
the minimum necessary to produce a fit and thus avoid the severe ophisthotonic
convulsions in which these accidents often occur. A very important factor
indeed is the training of the nurses who handle the patient during the convulsions
to know of the possible injuries, and especially in the case of dislocations, to
know how they may be prevented.

The occurrence of status epilepticus is uncommon with cardiazol and
repeated convulsions are rarely seen as they are with triazol. This com-
pliation is not usually dangerous and can be ended with intravenous injections
of phenobarbitone.

Late Complications.—The second group of complications includes those
which appear after the actual convulsion is over, and some of these, though
uncommon, are serious. There is a tendency, noted especially by Harris
(1938), for septic conditions such as boils, tonsillitis, and whitlow to appear
during treatment, and, in particular, patients seem susceptible to lobar
pneumonia. Among 523 cases, Ross (1939) described three fatal cases of
pneumonia in the three-week period following a course of treatment and one
fatal case of pulmonary abscess. Van Craaf, Montfrans, and Brouwer (1938)
describe four cases in which acute lesions demonstrable by X-ray appeared
during treatment but subsided in a few days. These may have been embolic
in origin. Pameijer (1938) describes seven non-fatal cases of pulmonary
abscess, and there is reason to believe that this is the most frequent pulmonary
complication. This worker also records seven cases in which latent and
unnoticed pulmonary tuberculosis appeared to have been activated by the
treatment. Harris and Birnie (1938) record a similar case among 18 cases of
stupor treated with cardiazol. The question whether it is justifiable to treat
young subjects with latent tuberculosis was discussed at the Munsingen Congress (Thumm, 1938; Meduna, 1937). It was thought then that, where the illness was of short duration and the prognosis good, and yet remission did not seem to be coming about spontaneously, it might be justifiable to take a slightly increased risk. The prevention of pulmonary complications, therefore, lies in the exclusion of cases of pre-existing pulmonary disease, the avoidance of aspiration of foreign bodies and septic material while the cough-reflex is absent, and in care in avoiding the mobilization of thrombi from the site of injection, which might produce small emboli and later pulmonary abscesses. It is essential that the patient should be in bed a few days before treatment begins and that the temperature and pulse should be carefully recorded during this period to exclude minor infective foci. Dental sepsis, and especially teeth which may break, must be attended to before treatment is commenced.

It seemed at first from the observations of Meduna, based on the electrocardiographic work of Dobozoy and Lax (1936) that convulsions had little adverse effect on the heart. Geraudel (1939), however, has studied the electrocardiographic records in the period following the fit in a series of cases and found that a temporary inversion of the T-wave in two leads occurred fairly often. He regards it as a sign of myocardial distress and an indication for cessation of the treatment. Schmitt (1939) has collected 68 records commencing at the clonic phase of the fit and found a number of abnormalities. In some cases there was a simple sinus tachycardia, similar to that seen in Graves' disease, while in others there were extrasystoles, both auricular and ventricular, which sometimes produced a pulsus bigeminus. In 10 of these cases the records were normal before treatment, and she concludes that cardiazol injections are able to produce minor myocardial lesions. McAdam (1938) also found disturbances in the electrical heart record, but these only persisted for a short period after the convulsion and were rather similar to the recent findings of Erickson (1939) in epilepsy induced during intracranial operations. McAdam has also observed that a reduplicated mitral second sound can often be heard in the period following the fit.

Pameijer (1938), in his investigations into the complications in 1,200 cases in Holland, encountered many cases of cardiac weakness during treatment and reports two cases of death due to this cause. Dick and McAdam (1938) have reported three cases of auricular fibrillation precipitated by the convulsions. It is clear, nevertheless, that cardiac complications are not frequent and that their incidence can be reduced, to some extent at least, if cases are excluded whose myocardial powers are thought unequal to and unprepared for the considerable effort involved in the treatment.

Complications in the Nervous System: Adverse Mental Changes.—In spite of the great rise in blood-pressure which occurs during the convulsions, the experimental evidence of minor lesions, and the apparent increase of strokes of the changes on the nervous system, gross disorders of this system appears to be rare and there is no case on record of severe vascular accident as a complication. One complication which was much feared in the early stages of the treatment was not recorded at all until Hobson (1938) described a case of
spontaneous epilepsy commencing after a course of cardiazol therapy. In this case the patient had five spontaneous fits after treatment had been discontinued, but they ceased after a month and with their disappearance the patient, who had improved mentally, relapsed. It does not appear from this that induced convulsions are likely to precipitate a permanent convulsive tendency.

One is apt, when considering the results of a series of cases, to pay most attention to the mental changes in the improved group. Examination of the unimproved cases, however, frequently shows that unfavourable changes occur and that the mental state has in fact been made worse, at least for the time being. Harris (1938) remarks that cases of catatonic stupor which do not recover frequently pass into a state of excitement which makes them difficult to nurse. Nightingale (1938) observes that cases that have been quiet and friendly may become mischievous and interfering after an unsuccessful course of convulsions. The unfavourable psychical effects of convulsions may be divided into two groups. First, increases in the psychotic manifestations and changes in behaviour which cause difficulties in nursing; secondly disorders of memory; and thirdly the rather vague personality changes observed in some remitted cases which are regarded by some as evidence of mental deterioration. Of the unfavourable psychical changes observed some are seen in connection with the actual injection and the period which follows it and others after the course of treatment is over. The first group includes the states of panic which occur when a subconvulsive dose is given. The states of excitement following the convulsion, are comparable to the fugues and furors of epilepsy, as the patient has little memory of what has happened. It is generally agreed that the anxiety attacks are to be avoided, as the patient usually has a very unpleasant memory of them and is likely to dread a repetition. The fugues, if the patient is prevented from harming himself, appear to do no harm, but close observation is necessary as suicidal attempts or attempts to run away are always possible. It seems likely that the incidence of such behaviour might be reduced, if care is taken that the patients are not made apprehensive before the injections by hearing other patients and thus having ideas of escape and hostility implanted in them, to be released in the post-convulsive period. Most workers have found that patients who have been stuporose or quiet often pass, during treatment, through a stage of excitement in which they are inco-operative and sometimes violent before improvement occurs. It is not unreasonable to expect that the first emotional responses after a long period of restricted affectivity might be somewhat uncontrolled, and Dynes' (1939) view that such reactions should be an indication for termination of the treatment seems a little unjustified. This worker observed that in three out of 10 unfavourable cases excitement and antisocial behaviour went on after the course was over, and Berrington (1939) and Harris (1938) have made similar observations. It appears that apart from these periods of excitement, which in Dynes' cases had subsided within 2 months, the form of the psychosis can be changed in a way that makes the patient more difficult to look after. It is at least as likely, of course, as Ross (1939) has pointed out, to have the opposite effect, difficult patients, while not
becoming fit for discharge, being able after treatment to work contentedly within their institutions.

A number of workers (Balta, 1939; Canseco, 1939; Dynes, 1939; Tooth and Blackburn, 1939; Weitbrecht, 1938) have now drawn attention to disorders of memory observed after courses of convulsions, and this, together with certain personality changes (Berrington, 1939) has been adduced as evidence of mental deterioration in the patients. The evidence for this will be dealt with in a later section.

Reported Results and their Significance

Although over 5,000 cases have now been reported in the literature, study of the available figures makes it evident that lack of uniformity in the collection of the material has practically destroyed its statistical value. As the method has gained more extensive application, the high recovery rates reported by earlier enthusiasts have not been substantiated; and even when consideration is restricted to cases of 18 months' or less duration, the remission rate continues to decline as more reports are added. In a review of results in these early cases up to the end of 1938, Reitmann (1939) has shown that the percentage of remissions at different hospitals varies from 7 to 100 per cent., and in a study of similar figures available in English-speaking countries, Kennedy (1939) has shown that the variation in results is far in excess of any that could result from chance distribution of cases. Not only are there great variations in the remission rate from year to year, but the total rates from different countries vary from 79 per cent. in Italy to 39 per cent. in Germany, a discrepancy which is again far too great to be accounted for by chance differences in case material.

The gross rate for complete remissions in 1,572 English and American cases of less than 18 months' duration was 38 per cent.; when cases of up to 10 years' duration were included, this percentage fell in most series to a figure not far in excess of that for spontaneous remission in comparable institutions. Apart from the errors introduced by the propagandist type of report, based on selected cases, the lack of uniform classification of the different grades of improvement has made only the numbers of complete remissions suitable for statistical treatment. Only rough impressions can be gained as to the amount of improvement in other cases, a matter for regret, as it is evident that a large number of patients are greatly improved, even though they are not capable of complete social rehabilitation. It is to be hoped that the suggestions of the Board of Control (Rees-Thomas and Wilson, 1938) for a uniform classification will be adopted. The scheme advised is a modification of Müller's (1937) classification, cases being divided into complete remissions, incomplete remissions, partial remissions, unimproved cases continuing to need hospital care, and deaths.

While the general rate for full remissions in early cases may be as high as the 38 per cent. quoted above, there is no doubt that in cases of over 3 years' duration the prospects of reversal of the schizophrenic process are slight indeed.

A difficulty which has not received adequate attention is the great frequency
of relapse after treatment. The importance of this can only be estimated in prolonged catamnestic studies such as those of Lehoczky, Eszenyi, Horányi-Hechst, and Bak (1939) are made. It seems probable that such studies will give a far more valuable impression of the effects of treatment than statistics based on the present methods of recording results. The frequency of relapse is very striking, and though it was early pointed out by v. Meduna, it has as yet been inadequately studied, apart from the work of the Hungarian schools.

In spite of the possibility of over-estimation, there seems little doubt that in most hands convulsion therapy has given results considerably better than the spontaneous remission rates for comparable case material. If comparison is made between the results of convulsion therapy and the spontaneous remission-rate at psychiatric clinics on the one hand and at hospitals for chronic cases on the other, the remission-rate after convulsion treatment is usually significantly higher than that occurring after the usual methods of treatment. Guttmann, Mayer-Gross, and Slater (1938), in order to obtain, for purposes of comparison, the remission-rate for methods other than shock-therapy in a prognostically favourable group of cases, followed up 280 schizophrenics admitted to the Maudsley Hospital and found that rather more than one-third recovered. This must represent the highest possible spontaneous remission-rate, and any treatment which improves on these results must be regarded as introducing a new therapeutic factor. Although convulsion-therapy may have done this, the margin cannot be a large one. Strecker (1938) has collected the spontaneous remission-rates from 11 sources in the literature, with a total of 581 cases, and finds an average of 24 per cent. When compared with the general results after convulsion therapy in all types of case, both recent and chronic, this again would indicate that the method may offer an improved therapeutic attack, though the difference is not a striking one. It is the speed of recovery, when it occurs, that has made the results appear more striking than they are.

In addition to comparison with spontaneous remissions, it is of interest to compare the results of convulsion therapy with those obtained by the two other methods which have been prominent in recent years, insulin shock and prolonged narcosis. In the survey published by Küppers the author is of opinion that the difference between the results of insulin therapy (30 per cent.) and cardiazol therapy (53 per cent.) is not to be taken too seriously as a comparison between the two methods. In their survey of results available up to April 1938, Rees-Thomas and Wilson come to a similar conclusion, and observe that those workers who are successful with either treatment tend to achieve comparatively poor results with the other, and that effective comparison is not likely to be obtained until a number of workers have had time to become familiar with both methods, and to have used them side by side in the same hospital. Reports from America indicate a similar state of affairs. In the State Hospitals of New York, Malzberg (1938) found a recovery rate of 23 per cent. with insulin therapy for cases of less than 1 year’s duration, while an analysis of Ross’s (1939) figures for slightly different material yields a percentage of 21 per cent. Using case material from the same hospitals, this worker obtained a remission-rate of only 10 per cent. for cardiazol treatment. This result has to be compared with
50 per cent. the remission-rate for all material published elsewhere than in New York State. It is evident that, although the results obtained by both insulin and cardiazol are better than the spontaneous remission-rates for the type of hospital from which they are obtained, it is not yet possible to make a fair comparison between them. It is noticeable that the results from psychiatric clinics are usually better with cardiazol, while those from mental hospitals are better with insulin. A possible cause for this difference may be the fact that, for legal reasons, paranoid cases, which are generally regarded as more suitable for insulin treatment, are more often sent to mental hospitals than to psychiatric clinics.

In the case of prolonged narcosis it is easier to make a comparison. The results obtained by the Zurich school, summarized in the papers of Klaesi (1922), Oberholzer (1927), Lutz (1930), and Monnier (1936), show that 62 out of a total of 258 cases were rendered fit for discharge by this treatment, i.e. 20 per cent., while the larger series of Meerloo (1933) shows a recovery rate of 33 per cent. in schizophrenic cases. These results are clearly not so high as the general level of the results of shock-therapy. The impression of English workers with this method of treatment is given by R. D. Gillespie in a critical review (1939) in which he observes that the remission-rate in recent psychoses does not exceed the spontaneous recovery rate, and that its principal use is to shorten the duration of illnesses which have a tendency to periodicity.

In general it is probably fair to say that patients who are constitutionally poor material are not likely to respond well to convulsion therapy or to any other therapy at present available. As Wortis (1936) has pointed out, the same rules for prognosis hold good now as before the introduction of shock-therapy. The evidence points to the fact that, when a case is likely to remit according to these rules, the appropriate method of shock-therapy will very often determine that remission and will bring it about earlier than any other method of treatment at present known.

Clinical Observations and Experimental Work

Since its origin, there has been an intense interest in the theoretical aspects of convulsion-therapy, and the experimental work that has been carried out has thrown a stimulating but sometimes confusing light on some of the problems of schizophrenia and of epilepsy.

Histopathology

The literature on the histological effects of induced convulsions is not yet very extensive and is confined to experimental work in animals, as no autopsy material has so far become available. Meduna in 1936 described the appearances seen after experimental camphor poisoning in rabbits, and recorded diffuse changes in the cell masses of the medulla and cerebellum. These changes consisted of vacuolization of cell protoplasm, chromatolysis of the Nissl bodies, and irregular staining and displacement of the nuclei, together with complete disintegration of some of the cells. There was little change in the
cerebrum and the distribution of the lesions as a whole suggested a toxic rather than a vascular origin. Some of these changes, at least, were attributable as much to the effects of the camphor as to the results of the convulsions per se. The cell changes themselves, too, were of the nature of the "primary irritation" of the German schools, which may be produced by either vascular or toxic causes. Kastein (1938) found that the most marked effects after cardiazol convulsions were in the cerebellum, cornu ammonis, and habenular region and considered them to be vascular in origin. Stender (1937), also working with cardiazol convulsions in rabbits, found no changes of importance, while Morsier, Georgi, and Rutishauser (1937) found only a hyperemic picture, probably due to terminal asphyxia. Nyberg (1937), in his careful studies of rabbit brains, demonstrated perivascular infiltrations which, in his illustrations at least, suggest the spontaneous encephalitis so common in that animal rather than a specific effect of the convulsions.

Reitmann (1938), in experiments on dogs, found circumscribed microscopic parenchymatous hæmorrhages distributed throughout the cortex. The vessels in these hæmorrhages appeared to be intact. He also found ischemic foci and areas of diffuse disturbance similar to those found by v. Meduna and Kastein. These findings suggested to him that there was a functional disturbance of the cerebral blood vessels. Scholz (1936) comes to a similar conclusion, and, from experiments on kittens in which the changes were more marked than in adult animals, regards the young nervous system as more vulnerable to the changes produced. In a later publication, Dreszer and Scholz (1939), using the benzidin method of Pickworth (1938) on cats, found differences in vascularity in animals killed at different stages of the convulsions. They conclude from these observations that a preliminary cerebral anæmia is followed by an hyperæmia during the actual occurrence of the convulsion. In his studies of the brains of animals subjected to convulsions from monobrom-camphor and thujone, Opper (1939) found areas of diffuse degenerative change scattered throughout the cortex, the cornu ammonis and basal regions being largely spared.

Strecker, Alpers, Flaherty, and Hughes (1938) examined the brains of monkeys in which a series of convulsions had been induced. They found small subarachnoid hæmorrhages in four out of seven animals, especially over the frontal regions, and in three animals there was vacuolization of the cytoplasm of the cortical cells. These workers remark on the slightness of the changes, especially in view of the fact that the total duration of the convulsions in these animals was far in excess of that to which patients are exposed in the longest courses of treatment. The majority of workers have regarded the histological findings as consistent with the effects of gross functional changes in the cerebral blood vessels, and especially of vascular "spasm." Ricker (1927) has, however, pointed out that the histological after-effects of vasoconstriction and of vasodilatation with vascular stasis cannot confidently be differentiated, and Meyer (1939) regards the evidence as insufficient as a basis for theorization as to the mechanism of causation. While some authors (Tooth, Dynes, Balta) have regarded the amnesias and other disturbances of mental function after cardiazol convulsions as related to brain-damage, such as is suggested by these histological
pictures, Spielmeyer and his pupils have pointed out that there are wide discrepancies between clinical and histological findings in such cases, and it is at present unsafe to accept the histological evidence as in any way explanatory of the clinical observations. It is upon the histological evidences of cell destruction, nevertheless, that Stief has based his theory of the action of convulsions by the therapeutic decimation of the cortical cell-units. It must be remembered, too, in interpreting these results, that the evidence available is based on experimental material and may bear little relation to the effects of convulsants in the smaller therapeutic doses. There is clearly room for much further work before the meaning of these data becomes clear in the light of other experimental approaches to the subject.

**Convulsions and the Vascular System**

The early observation that the cardiazol convulsion was accompanied by phenomena referable to changes in the vascular system has led to a revival of interest in the vascular theory of epilepsy, and if, at the end, this theory seems no more acceptable in the case of induced than of idiopathic epilepsy, it has at least stimulated some interesting experimental work. The subject has been investigated in a number of ways.

**Blood-Pressure.**—Meduna (1934), in his early work, demonstrated a rise of blood-pressure during the convulsion, the systolic pressure being most affected. It seemed likely that this was largely due to the muscular effort of the convulsion, as there was very little rise when a subconvulsive dose was given, even though cardiazol is a powerful cardiac stimulant. The experiments of Coombs and Pike (1931) with cats made this explanation seem a reasonable one. These workers had shown that with convulsions induced by monobrom-camphor, after a pre-paroxysmal fall there was a rise of blood-pressure with the onset of the actual convulsion, and that this rise could be abolished completely if the muscles were rendered flaccid by spinal transection or by curare. Meduna found no change in resting level after the convulsion but Harris (1938) found that this was often raised and Briner (1937) demonstrated a consistent rise of resting level throughout the course of treatment in many of his patients. In a recent careful study of 15 cases Guttmann and Reitmann (1939) have shown that after the injection there is a preliminary rise of pressure, but that at the time of onset of the fit there is a sharp fall, which is followed by a rise as the clonic stage comes on. They observe that this sudden rise after a fall represents a considerable strain on the cerebral vessels and may account for the frequency of small hemorrhages in the histological picture. These workers also investigated the effect of non-convulsant doses of cardiazol and found that these caused a rise of blood-pressure dependent in degree on the dosage and on the initial level. They found that the nearer the dose approached the convulsant threshold the higher was the rise of pressure. This suggested to them that the rise in pressure might be a determining factor in producing the fits, especially as amyl nitrate and other hypotensors were known to inhibit them. When, however, the pressure was artificially raised by means of intravenous injections of benzedrine hydrochloride
fits did not occur with maximum non-convulsive doses, even though the pressure at which the convolution occurred was greatly exceeded. It would thus seem that the rise in blood-pressure is not an important factor in determining the onset of the convolution.

Vascular Spasm.—Reitmann (1938) in his histological studies on dogs, and later Dreszer and Scholz (1939), regarded the ischaemic necrosis found after convulsions as probably due to an intense temporary vasoconstriction. This view led Köst (1938) to try the effect of amyl nitrate, which has a reputed vasodilator effect on the cerebral vessels. By giving inhalations of amyl nitrite in ether he was able to inhibit the convulsions in all his cases. This result was confirmed by Denysen and Watterson (1939), who used pure amyl nitrite and also sodium nitrite and histamine, and interpreted the results as indicating that the inhibition of the fit was due to prevention of cerebral vascular spasm. This neglected the possibility that, by its peripheral vasodilator action, it might cause sudden enlargement of the vascular field and divert much of the blood, and with it the cardiazol, that would otherwise reach the central nervous system in greater quantity. That amyl nitrite and similar drugs do, in fact, cause a significant dilation of cerebral vessels is by no means certain, though it is suggested by the work of Norcross (1938) on the cerebrospinal fluid pressure and by that of Wolff (1929). That histamine and amyl nitrite increase the blood flow through the brain, in some circumstances at least, is shown by the work of Schneider and Schneider (1934) but it must be recalled that this was carried out under barbiturate anaesthesia. Acetylcholine would appear to cause cerebral vasodilatation as judged by direct observation (Wolff, 1929) or by cerebrospinal fluid pressure changes (Norcross, 1938; Wolff, 1929). Assuming that two other choline derivatives, carbaminoyl choline (Doryl) and acetyl-β-methylcholine (Mecholy) had a similar dilator effect, Watterson and MacDonald (1939) showed that these had an even more constant inhibiting effect on the convulsions. They found, however, the caffeine, which in animals, at least, is a cerebral vasodilator (Finesinger, 1932; Norcross, 1938), had no such inhibiting effect, and it is to be noted that caffeine has little, if any, peripheral vasodilator action.

Watterson and MacDonald (1939) point out that increase in the cerebral bloodflow may have at least as much to do with the inhibition of convulsions as the supposed prevention of vasoconstriction. The observations that ephedrine (Leibel and Hall, 1938), which is a peripheral vasoconstrictor, and sodium cyanide (Watterson and MacDonald, 1939), which also raises systematic blood-pressure, both inhibit the convulsions are perhaps in favour of this view, but the question of this mechanism is still a very open one.

Even if cerebral vasodilators are able to inhibit the convulsions it is by no means certain that these are actually caused by vasoconstriction, and the work of Forbes and Cobb (1938) suggests that sufficient constriction is not possible in the cerebral vessels to cause demonstrable lesions due to anoxæmia such as are the foundation of the vasoconstrictor theory. Nor does the work of Gibbs and Lennox (1938) make it appear that the reduction in blood-flow during a fit is enough to produce a very marked anoxæmia. It is thus of interest that Meduna (1937) records that it was not possible to observe surface vasocon-
striction in the cortex by direct vision at any period after the injection of convulsant doses of cardiazol. Many of those who favour the vasoconstrictor theory of the causation of convulsions regard a cellular anoxia as the intermediate mechanism. Even if vasoconstriction occurs and can be sufficiently intense to precipitate a convulsion, it seems unlikely that this effect could be produced in the short period which elapses between the time the drug passes the carotid sinus and the onset of the convulsion. Watterson and MacDonald (1939) have shown that the cardiazol reaches the brain only just before the onset of the convulsion. By injecting 0·5 c.c. of 2 per cent. sodium cyanide intravenously one second before the cardiazol, they demonstrated that the carotid-respiratory reflex (Bernthal, 1938) takes place little more than one second before the onset of the convulsion. The convulsant must thus pass the carotid sinus, where this reflex is initiated, only a moment before the fit begins. This observation suggests that, in accordance with the original view of Georgi (1937), the effect of cardiazol is a direct chemical one on the cerebral cells. If this is the case the different parts of the brain might be reached by the drug in order of their vascularity. This might account, perhaps, for the differences in pattern between the epileptic and the cardiazol fit and the greater constancy of the latter. The epileptic convulsion arising in foci in any part of the brain, and spreading by a process of conduction, might be expected to have a different and less constant pattern.

Blood-flow.—The most interesting work by this approach is that of Leibel and Hall (1938). These workers, using a modified thermoströhmur, recorded the changes in blood-flow in the carotid artery and in the meningeal branch of the jugular vein in a number of rabbits. They observed that, at the onset of a cardiazol convulsion, the blood flow in both vessels decreased to between one-half and one-fifth, after which it returned to the normal in an irregular manner suggestive of the presence of widespread arteriolar effects. These authors are of the opinion that this reduction in blood flow represents a severe and prolonged cerebral anemia, and in view of the temporary beneficial effects of depressant substances on schizophrenic states this may be of importance in relation to the therapeutic effects of the convulsion.

In view of the observation that the peripheral circulation in catatonic patients with vascular stasis improved rapidly during convulsion treatment, it was of interest to know whether this circulatory improvement had any relation to the improvement in mental state. Harris (1938) observed, as had Briner (1937), that a gradual rise in blood-pressure accompanied the clearing up of peripheral stasis, but found that this was not necessarily accompanied by mental improvement. Many of his cases, however, were of long standing and the possibility of clinical improvement may have long passed.

Cerebrospinal Fluid Pressure.—A further method of investigating the vascular changes during induced convulsions is afforded by a study of pressure-changes in the cerebrospinal fluid. Niketic and Susic (1938) have demonstrated a sudden increase in pressure with the onset of the convulsion. This is indicative either of venous congestion due to the mechanical effects or of a very great vasodilatation, and may well be due to both these factors.
**Effects of Convulsions on Catatonia-like States in Animals**

Since studies in disorders of thought depend very largely on the interpretation of subjective experience, they cannot be approached by the method of reproducing the disease in the non-speaking experimental animal. Even if abnormal motor states could be produced resembling those of the schizophrenias in which motility is predominantly disordered it would be of some assistance. It is claimed that this can be done (de Jong and Baruk, 1930; Baruk, 1933), but this view is very open to question. A comparatively wide variety of substances are able to produce a cataleptoid state if given to appropriate animals, such as acetyl choline (de Jong, 1931), b.coli toxin (Baruk, 1933), carbon dioxide (Baruk, 1933), several benzene derivatives (de Jong, 1931) and somnifaine (Claude and Baruk, 1928). Similar states have been produced by thyroparathyroidectomy (Parhon and Urechia, 1908), by operative lesions near the third ventricle (Colucci and Sciuti, 1902) or retromammillary region (Ingram and Ranson, 1934), and by the intracistemal injection of deuternum oxide (Hermann and Barbour, 1938). None of these methods is at all constant in its effects, but with bulbocapnine, introduced by Peters in 1904, the effects, though brief, are fairly constant. While the syndrome produced by this drug has objective features in common with clinical catatonia, it has been pointed out (Schaltenbrand, 1929; Ferraro and Barrera, 1932) that it has symptom-components in common with other hypomotile states, such as post-encephalitic Parkinsonism. Some of the substances which produce temporary remissions in catatonic states, such as carbon dioxide (Loewenhardt, Lorenz, and Waters, 1929) or cocaine, are able to relieve this "bulbocapnine catatonia" (Buchman and Richter, 1931; Paterson and Richter, 1933). Kennedy (1939) has shown that convulsions have no effect in preventing the cataleptoid condition from appearing in the monkey, and that in the period following the convulsion the catalepsy is greatly increased. Gutiérrez-Noriega (1938), on the other hand, found that, with different doses of bulbocapnine in dogs, the catalepsy was improved after convulsions. The work of Quastel and Jowett (1939) on cerebral oxygen consumption during bulbocapnine intoxication makes it probable that any effects observed are due to a cumulative increase in the anoxia due to the convulsion. These findings are of interest in view of Friedman's (1937) observation that in camphorcardiazol therapy patients often showed profound catalepsy after their convulsions, as well as deep cyanosis. It would seem that a similar process is at work here, the camphor providing a prolonged state of lowered cerebral activity and the superadded convulsions bringing on catalepsy.

**Effects of Convulsions on Metabolism**

Studies of the effects of shock-therapy in this sphere are of especial interest, as it cannot be doubted that there is a profound effect on the metabolism of the central nervous system. Clinically it is evident that cerebral function is very sensitive to changes in oxygen tension such as are seen in anoxæmic states and at high altitudes, and also to alterations in the amount of available carbohydrates as in hypoglycaemia. It is just in this sensitivity to lack of oxygen and in its need for a continued supply of carbohydrate that the metabolism of brain-
tissue differs from that of other tissues. Wortis (1934) has furthermore demonstrated that the grey matter, especially of the cerebral and cerebellar cortices, has the greatest oxygen consumption, a fact which might be expected from the relative richness of their vascular supply.

The oxidation properties of the different kinds of brain-tissue can thus be interfered with by a gross lack of oxygen, by a deficiency of available carbohydrate or by a specific effect on the intermediate processes in cell oxidation, such as the intracellular enzymes which have been shown by Warburg to play an important part in making oxygen utilizable by the cells. Dameshek, Myerson, and Loman (1934) have shown that sodium amytal, which has such remarkable effects in procuring temporary remissions in catatonic stupor (Bleckwenn, 1931), causes a reduction in the utilization of oxygen and glucose by the brain. In understanding the effects of shock-therapy the experimental study of the metabolism of brain-tissue has been carried out (Wortis, 1935) mainly by three methods: first the Barcroft-Warburg technique, by which small amounts of living brain are kept under nearly physiological conditions and the oxygen consumption and carbon-dioxide elimination are measured; secondly by the method of arterial and venous puncture, whereby the concentration of oxygen, glucose, and metabolites are compared in the blood entering and leaving the brain; and thirdly by placing slices of brain in physiological solutions which support their nutrition, and determining by chemical analysis the amount of absorption of nutritive material and the production of the end-products of tissue metabolism.

Wortis (1933), using the Barcroft-Warburg technique, has shown that the respiratory quotient of brain-tissue in man and several animals is approximately unity, indicating that its nutrition is necessary to find out by which of these means brain-metabolism is altered or by what proportion of each. In insulin-therapy it is clear that the lack of available carbohydrate is likely to be the principal factor, but in convulsion-therapy the mechanism is less obvious. Wortis (1936) has shown that, in contrast to insulin, cardiazol causes no reduced oxidation in brain tissue removed immediately after the convulsion. It has also no effect on the metabolism of brain-slices immersed in physiological solutions.

Himwich and his co-workers (1938) studied the haemoglobin saturation (i.e. \( \frac{\text{oxygen content}}{\text{oxygen capacity}} \)) of blood from the femoral artery and jugular vein at different stages of the convulsion and have shown that towards the end this fell to 50 per cent., and concluded that convulsions cause a depression of cerebral function by decreasing the amount of oxygen available for the combustion of carbohydrate. There was no lowering of the blood-sugar in their cases, and Kerr and Antaki (1937) have also failed to demonstrate any reduction in carbohydrate content in the brain-tissue of animals after the convulsions.

There are a number of clinical similarities between the phenomena seen in anoxia and in shock-treatment. Fraser and Reitmann (1939) have observed the effects of causing patients to breathe very low concentrations (2 per cent.) of oxygen in nitrogen. The neurological phenomena bore no very marked
resemblance to those seen in induced convulsions, and, though unconsciousness and myoclonic movements were produced, there were no convulsions. This is in accord with the animal experiments of Armstrong and Heim (1938), who were unable to produce fits by anoxia, and of Simpson and Barker (1938), who subjected a number of epileptic patients to low concentrations of oxygen without inducing fits. Gellhorn (1938), from his animal experiments, however, concludes that anoxia is probably the principal factor in producing the effects of shock-therapy on the organism.

A good deal of work has been done on the general metabolism of patients during cardiazol treatment, especially on carbohydrate metabolism, on the pH of the blood and on the quantities of various substances in the blood, and some of these may throw some light on the effect of the drug. The theory of Georgi (1937), that the changes during a convulsion may be compared with the changes in the first phase of insulin-treatment, does not find much confirmation in the work of Maurer and his co-workers (1938), Harris (1938), and Walk and Mayer-Gross (1938). These workers have found little more than a simple rise of blood-sugar during the convulsion, which gradually subsides. Harris has also found no significant change in the form of the response to the ingestion of sugar before and after treatment. The fact that the majority of patients gain weight during treatment cannot be related entirely to carbohydrate metabolism, as increased appetite is usually a feature of the mental change. Harris has shown that this weight-increase has no relation to the occurrence of remissions.

Maurer and his co-workers (1938) have shown that, in the course of the convulsion, the pH of the blood may fall to the lowest levels compatible with life, but that there is no variation in cases where convulsions do not occur. It is to be presumed that the change is largely due to the enormous output of lactic acid which occurs as the result of the muscular effort of the convulsions. This change in pH is in exactly the opposite direction from that which occurs in insulin-therapy, although it may be followed by an over-compensating alkalosis which actually causes vomiting. This may be significant when it is recalled how difficult it is to cause any extensive change in pH in schizophrenics by the administration of alkalis (Golla, Mann, and Marsh, 1928).

These workers, and others (Bailey, Smith, and Moersch, 1938; Katzenelbogen, 1938), have also studied the changes in calcium and phosphorus content in the blood, and find that, while the former stays at a fairly constant level, the inorganic serum phosphorus is increased up to 100 per cent., presumably due to the replacement of the phosphate of the muscle-cell by lactate during the violent muscular contractions.

**Neurological and Electroencephalographic Observations**

Although it has been possible to induce fits in predisposed subjects for purposes of study by means of the hyperventilation method of Foerster and by electrical stimulation at operations, the clinical use of chemically induced convulsions has provided an opportunity of more accurate study of changes in function and metabolism during the convulsion itself. In most respects the
convulsions may be regarded as closely comparable with those of idiopathic epilepsy. The reflex changes, amnesia (Canseco, 1938), equivalents (Walk and Mayer-Gross, 1938), mode of recovery (Cohen, 1938), biochemical changes (Meduna, 1934), electrocardiographic changes (Gjessing, 1938; Erickson, 1939), and some of the pupil changes (Wespi, 1937; Birkmeyer, 1937) are all essentially similar. Nevertheless, the pattern of the cardiazol convolution is very constant and has some special features of its own. The preliminary cough and sudden opening of the mouth, which so often produces dislocation of the jaw, are not seen in idiopathic epilepsy.

Study of the brain potentials during convulsion-therapy has yielded valuable information as to the mode of spread of the abnormal cortical activity, and has assisted in explaining this difference in convulsion-pattern. Cook and Grey Walter (1938) were the first to study the brain rhythms during the convulsion. They found that a few seconds after the injection abnormal waves appear in all areas, but that a few seconds later there is an increase in potential and a drop in frequency in an area which they localize in the superior frontal convolution. From this area the large slow waves spread over the rest of the cortex during the course of the convolution. After this there is a period of comparatively little activity until normal rhythm returns. In essentials Rubin and Wall (1939) confirm these findings, though their localization of the starting-point from which the slow waves spread is less definite and rather nearer to the motor area. In the period following the convolution, when the bipolar leads of Cook and Grey Walter recorded a relative inactivity, they, using monopolar recording, were able to detect disappearance of the slow waves until the record returned to normal.

These observations are comparable with those of Gibbs, Gibbs, and Lennox (1938) in idiopathic epilepsy, except that the origin of the discharge in these cases is not always from the same area. This possible localization of the starting-point of abnormal activity in the area $\alpha \beta$ of Vogt, to which Foerster and others attribute an epileptogenic function, is clearly of the greatest interest.

In patients who have had an injection insufficient to cause a convolution, but enough to cause a marked emotional response with restlessness and anxiety, Cook and Grey Walter found a period of generalized irregular cortical activity which persisted for some hours, and this, like the clinical state, disappeared at once if a true convolution was induced by a second dose. Rubin and Wall have shown that the changes in cortical electrical activity can be correlated with the different stages of muscular activity demonstrated by high-speed motion-pictures and electromyograms by Strauss and Landis (1938), the first clonic stage, tonic stage, and second myoclonic stage each being accompanied by its characteristic electroencephalographic rhythm. They have also pointed out that the characteristic slow waves, which are seen only in the major convolution, correspond to a drop in $p\text{H}$ in the blood which also occurs only when an actual fit has taken place. This finding is of especial interest in view of the work of Dusser de Barenne, McCulloch, and Nims (1938), who have found that a reduction of $p\text{H}$ in the cortex is accompanied by a reduction of amplitude and frequency in the potentials arising from it.
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Patients whose electroencephalograms have been followed during a course of treatment do not usually show any significant change in the resting rhythms as the result of treatment, and Goodwin, Lloyd, and Hall (1938) have subjected rabbits to long series of convulsions without their having any marked effect on the form of the record or altering the course of the convulsive response. There is thus no evidence that the convulsion is able materially to alter the cortical rhythm or to introduce an abnormal one. MacMahon and Grey Walter's (1938) cases, on the other hand, suggest that an abnormal rhythm may be removed.

Some attempts have been made to compare the electroencephalographic records of schizophrenic and epileptic patients. Although no definite abnormality in the brain potentials has been found common to all schizophrenics, different abnormalities have been shown to occur in a fairly large proportion of cases. Jasper, Fitzpatrick, and Solomon (1938) could find no single specific form of activity which might distinguish patients diagnosed as schizophrenic from control groups. On the other hand, when making comparisons between schizophrenic and epileptic patients, they found that, while no definite contrast could be made out between the two groups to support the theory of biological antagonism (Meduna, 1934), there was a tendency for certain characteristics to predominate in each of the two groups. The cases diagnosed as schizophrenic and epileptic tended to fall at opposite ends of a scale based on the amount of brain potential activity of frequencies at or below the normal frequency of the alpha-rhythm. The schizophrenic group showed less of these slower waves. On the other hand, Gibbs, Gibbs, and Lennox have pointed out many electroencephalographic similarities between the two groups; MacMahon and Grey Walter observed a true delta-wave discharge in three cases of schizophrenia and showed that this disappeared with clinical recovery, in one case spontaneously and in two cases after convulsion-therapy. It is useless to speculate too much at present on the significance of these findings, but they are certainly very striking.

Psychological Aspects of Convulsion-Therapy

The psychological effects of convulsions, as well as their effects on mental function, have aroused great interest not only on account of their bearing upon earlier work on the psychopathological significance of the convulsion in general, but because of the relation of this newer method of treatment to the psychotherapeutic approach. A fair number of observations are now available on the effects of the induced convulsion on the psyche, especially in relation to perception, memory, and emotional tone.

Schilder (1939) has studied the phenomena observed in the half-hour following the convulsion. He observes a marked difficulty in remembering the names of objects, a great tendency to perseveration and to paraphasia, and also difficulty in copying the gestalt patterns devised by Bender (1935), with a tendency to revert to primitive and archaic forms. These observations may be taken to indicate a profound organic disturbance of form-function.
In the affective sphere this period is characterized by emotional lability and overreaction and the formation of crude transferences. Cohen (1939) has studied the order in which function returns as the patient emerges from the convulsion, and finds that crude sensation appears first, followed by coarse sensory discrimination; then the ability to focus attention on objects, followed by the ability to use them correctly. Memory is the last function to return, and, like other workers, Cohen finds that the amnesia becomes progressively delimited during the hours following the convulsion.

The memory defects associated with induced convulsions may be divided into two groups. The first of these is the retrograde amnesia in immediate association with the fit, which has been observed since the inception of the treatment. It may be regarded as in every way comparable to the amnesias associated with idiopathic epilepsy. Since it is the aim of the treatment to produce epileptiform convulsions, these amnesias are not to be regarded as an unfavourable effect, as they are an integral part of the convulsion. These immediate amnesias are said (Walk and Mayer-Gross, 1938) to be more marked with triazol 156 than with cardiazol.

The second group, that of memory disturbances persisting when the course of treatment is over, was not observed until much later. The condition has not, in fact, been studied over a sufficient period of time to establish whether it really is as temporary as would appear. Plattner (1938) was the first to notice that after "summation" therapy with insulin, Korsakoff-like memory disturbances, which usually disappeared after 4-8 weeks, were not uncommon. Weitbrecht (1938) also observed memory disorder after courses of cardiazol, but as some of these cases had had psychoses of long standing, he pointed out that it was difficult to be sure that the defect was not due to the effects of a prolonged psychosis rather than to the convulsions. He was inclined, also, to seek a psychopathological rather than a physical explanation for the amnesias.

In demonstrating minor lesions in the brains of dogs after convulsions, Reitmann (1938) drew attention to the memory disturbances observed in the human clinically. Two of these cases, who had difficulty in recalling addresses, names of friends, dates, and similar material, were published by Balta (1939). Tooth and Blackburn (1939) have also observed that nine out of 16 patients treated with convulsions had memory difficulties at the conclusion. Questioning of the relatives revealed that these patients had difficulty in remembering names and were very absent-minded. One patient who had learned shorthand in the months preceding her breakdown had great difficulty in remembering any of it after her psychosis had remitted, though she found it very easy to relearn. She was also frequently embarrassed by being unable to remember the names of friends, and when playing tennis often forgot the score. These disabilities ceased to be evident after six months. Another patient was noticed by her husband to be forgetful and careless in her housework, but after 8 months, apart from the fact that she had to use a shopping-list for even a small number of articles, there was no obvious disability.

These workers point out that this type of memory disorder is unlike that found in a dementing schizophrenic psychosis and resembles that seen after
epilepsy or concussion. They regard the changes as probably related to the minor pathological changes which, by analogy with animal experiments, presumably occur in the nervous system after convulsions. Just as it is difficult to prove that these changes are irreversible, so it is difficult to prove the contention of those (Berrington, Dynes, and Tooth and Blackburn) who hold that these reductions of mental efficiency, which certainly recover to a large extent at least, represent evidence of actual permanent mental deterioration. In an attempt to determine if this memory disorder is accompanied by a true deterioration, Tooth and Blackburn have applied the method of Babcock (1930) and shown that, in their cases, the ability with vocabulary tests was greater than with other tests which normally standardize at the same level, a fact which is taken to indicate deterioration. In comparing their findings in spontaneously remitting schizophrenics, in treated general paretics, epileptics, and convulsion-treated schizophrenics, they showed that there were close similarities between the post-convulsive and organic-deterioration groups. Although there has been some confirmation of Babcock's work (Wittmann, 1933; Gilbert, 1935), the validity of this or of any other test as an indication of irreversible mental deterioration is far from generally accepted.

It is very difficult to arrive at a satisfactory interpretation of the effects of induced convulsions on memory, as several factors may operate in their causation. The immediate amnesia for the fit and a period of time preceding and following it may be, as Schilder (1939) points out, perpetuated psychogenically to avoid recalling the unpleasant circumstances of the anxious period before the fit, but this does not seem to be a mechanism of great importance. The later memory disorders have some points in common with those seen in epileptics, such as the frequent difficulty in recalling names and detailed material. The way in which Tooth and Blackburn's patient forgot shorthand after convulsions, only to relearn it with great ease, is comparable to the "lernersparniss" phenomenon. On the other hand, there are similar disturbances found in other forms of cerebral pathology, such as vascular accidents, which clear up in a few months in exactly the same way. Although it is unlikely that after a series of convulsions which leave behind a considerable disturbance of memory there is no irreversible change in the nervous system, it seems unjustifiable, without more prolonged study of the case-material, to suggest that a process comparable to epileptic dementia occurs in these patients. Even with a picture strongly suggesting deterioration such as is seen in the cases reported by Dynes (1939), it is difficult, as Weitbrecht points out, to be sure how much is attributable to the convulsions and how much to the effects of a psychosis which, in these cases, was of over 3 years' duration.

It would seem that for evidence of deterioration it is at least as important to look for evidence of changes in personality and alterations in social relationships, but there is a paucity of observations on this point. There is certainly no record of the development of the antisocial traits associated with the chronic epileptic. Berrington (1939) is inclined to interpret the frequently noted lack of curiosity of the recovered patient about his illness, his lack of true insight into his former abnormal mental activity, and his increased preoccupation with
the simple processes of eating and living, to the exclusion of more imaginative and intellectual topics, as evidence of a deterioration of the higher mental functions.

In the affective sphere the disordered emotional responses of each post-convulsive period are accompanied by a series of changes in the attitude of the patient towards his attendants as the treatment progresses. In the early stages of remission emotional reactions of a primitive kind are manifest, either as the result of the sudden termination of a period of restricted affectivity or as the result of the shock effect of the treatment, and these subsequently become modified as the patient approaches normality. In three cases reported by Kennedy (1937) this process took place in a regular order, an excited and anxious phase being followed by an erotic-euphoric one with a strong positive transference, which gave way in turn to an attitude of reasonable co-operation.

The tendency to euphoria in the early stages of treatment was recognized from the first by Meduna, Lehmann-Facius, and others. There is no doubt that a very definite transference to the physician develops in a large proportion of cases. It is at first crude and infantile, but later more mature in form, and Schilder (1939) observes that this transference persists when treatment is over and can be used psychotherapeutically when the patient is being assisted to re-adapt himself to normal life. Dynes has drawn attention to the fact that, in cases which do not recover, the exaggerated mood-states and euphoric-hypomanic conditions provoked by the convulsions may persist for some time and cause difficulty in managing the patient.

Rees-Thomas and Wilson found that the nurses who were looking after patients who had convulsions thought that they had the effect of making the patient more accessible and communicative, and it is certain that their effect is to produce a state of increased co-operation which it is possible to exploit from the very beginning in the interests of their re-adaptation to normal life, by giving occupational therapy graduated according to the progress of the treatment. Ellery (1937) also comments on the use that can be made of the patient's new desire to communicate with those around him.

Many writers have spoken of the patient's attitude to the treatment and of the need of avoiding the fear of further injections which is sometimes aroused by their experience; some of the methods of avoiding these unpleasant effects have already been discussed. Many of the patients who object to and fear the convulsions are unable to give very definite reasons for their objections, and it would seem that while the memory of the unpleasant feelings has been lost the affective reaction has stayed with the patient, and caused him to rationalize his refusal of treatment. Starks (1938), in comparing the subjective aspects of insulin and cardiazol therapies, observed that the majority of his convolution patients found the treatment unpleasant, one quarter of them admitting to a fear of death in connection with the injections. Gillespie (1939) found that only three of 42 patients found treatment so unpleasant that they actively resisted it. He was able to obtain the accounts of the subjective sensations of 23 patients, the majority of whom found the treatment unpleasant in some way. He found a great variety of auræ preceding the fits, including feelings of unreality, flashes
of light, hallucinations of hearing, thoughts of a sexual nature, and pungent smells. Like other workers, he notes that a large proportion of the patients noticed unusual smells for some time after the convulsion.

This worker also improved our knowledge of the subjective aspect of this treatment by himself submitting to it. After an injection of 10 c.c. he felt his body turning, then "very rapidly something seemed to move in my arms and thorax and to pass up to the base of my neck, where it stopped and increased in intensity." He states the onset of unconsciousness was not unpleasant and felt like the onset of normal sleep. After the fit, "At first I could remember nothing of the morning’s events, including the injection, and even the day before seemed indistinct." This amnesia wore off in the course of a day.

The explanation of the remissions which occur as the result of shock-treatment has provided a difficult problem to those who regard the schizophrenias as largely psychogenic in origin. The treatments had not long been in existence, however, before theories had been advanced to explain the improvement on psychoanalytic lines.

Jeliffe (1937) regarded the effects of insulin-shock as attributable to the fear of annihilation which causes less vital conflicts to be forgotten in the urgent need to adapt. Schilder (1939) believes that convulsion-therapy operates in a similar manner and refers to the previous studies of Clarke (1917), who claimed that psychologically the epileptic experiences death and rebirth in the fit. He regards the improvement and euphoria of the cardiazol patient as due to the elation and joy of rebirth, which allow him to build up his relations with other people anew. This concept of the struggle between life and death in shock-treatment had been previously discussed by Humbert and Friedemann (1937).

Schilder has commented on the nature of the insight found in recovered patients. He draws a distinction between the type usually found, in which the patient, in looking back on his past behaviour, realizes that by normal standards he has been behaving foolishly, and the dynamic insight of the patient who has come to understand and to leave behind his symptoms as the result of psychotherapy.

He feels that use should be made of the transference-situation set up by the treatment, to obtain this dynamic insight by means of psychotherapeutic talks with the patient when the course of convulsions has been completed.

It has been generally agreed at the conferences held on this subject that some sort of psychotherapeutic adjunct to the treatment is necessary, and, as Meduna has said, it has both a biochemical and a psychological aspect. It is at least necessary to allay the fears of the patient and to keep him employed with a graduated programme of occupational therapy until he is able to co-operate sufficiently to discuss his return to his former life. After this he must at least be regarded in the light of a convalescent who needs a little help and encouragement in taking over once more his full responsibilities.
Theoretical Aspects of Convulsion-Therapy

The theoretical basis which led to the first trial of the induced convulsion as a therapeutic agent was early recognized as at least not wholly explanatory of the changes produced, and there have been many attempts to rationalize the purely empirical use of the method which has followed. Although much of this theorization has been loose and ill-founded, some of the possibilities are worthy of mention. The suggestions involve psychological and humoral mechanisms as well as effects on the central nervous system.

Psychological.—The drastic nature of convulsion therapy has led to its being compared with the turntables, duckings, and floggings which were meted out to the mentally afflicted of earlier days. There have been many accounts of stuporose patients whose condition has remitted following a profound psychic shock and the beneficial effects of convulsions may be contributed to in this way. In the case of chronic catatonic patients the extra attention which they receive and the change in routine may also assist their recovery. If some schizophrenic states are to be regarded as withdrawal reactions from a difficult environment, the immediate necessity of adapting to the "assault on the person" (Meyer) provided by the convulsion, may cause a temporary suppression of less important issues and force return to normal contacts. The "death-threat" theory of Jeliffe (1937) and Schilder (1939) may be regarded as a psychoanalytic elaboration of this theme. One of the objections to this view is the fact that subconvulsant doses which produce powerful fears and affective reactions are less effective than convulsant doses, the effects of which leave far less impression on the patient.

Theories involving the Nervous System.—Stief, in his histological studies on animals after prolonged insulin-shock (Stief and Tokay, 1935), found, as had Schmid (1936), evidence of cerebral damage and cell-outfall. He considers (1938) that the insulin may have a selective action on diseased functional units and by this means eliminate those which are the cause of the mental state. In the case of convulsions he considers that instead of lack of glucose, anoxia brought about by vascular spasm is the intermediate mechanism. It is difficult to criticize this view as there is, as yet, insufficient evidence that early schizophrenia is related to abnormal function in some of the neurones.

The effects of convulsion-therapy have revived interest in the mechanism of the temporary remissions produced by carbon dioxide (Loewenhardt, Lorenz, and Waters, 1929), sodium amytal (Bleckwenn, 1934), and other depressant substances. These results have recently been reviewed by Berrington (1939). It seems possible that these substances have a depressant effect principally on the cortex and produce brief remissions during the period of their action, and that the late effects of convulsions and of hypoglycaemia may be an incomplete damage which depresses the same functions in a more permanent manner. If this were so, the remitted patient would be expected to be altered in some way, just as the emotional behaviour and motility are only approximately "normal" in the amytal remission. There is much support for the view that this is the case (Balta, 1938; Berrington, 1939; Dynes, 1939).

The electroencephalographic observations of Jasper, Fitzpatrick, and
Solomon (1938), who find in catatronics evidence of greater, rather than less, activity in the cortical potentials, is here of interest if it is supposed that in the process of remission an excessive abnormal functional activity is replaced by a reduced one of normal type.

It may be, however, that the changes which occur are not so much the result of structural changes but of alteration in the nature of the action of the functional units in the brain. Birkmeyer (1938), for instance, suggests that after the convulsions there may be a general depression of activity, which, when it is built up anew, becomes normal activity; a similar view was taken by Angyal (1937) as to the mode of action of insulin-shock.

The question thus arises as to whether the patient secures his re-adaptation to normal life at the expense of a permanent lowering of functional efficiency. He may, in the language of chess, be sacrificing a piece to win the game. How much the patient is handicapped by these losses can only be found out by a careful comparison of his pre-psychotic personality and efficiency with his state when the illness and its treatment are over. From the point of view of social adjustment he seems to be little the worse.

Another possibility presents itself: since the activity of cerebral functional units is continuous whether the individual be active or stuporose, it may be supposed that conduction from one unit to another is occurring at all times, even though it does not result in thought or action. It might be compared to the ceaseless conduction of impulses by the muscle of the auricle. If, in schizophrenic states, this continuous activity becomes abnormal in type so as to produce a disorder of conduct, just as the abnormal conduction of auricular fibrillation produces abnormal ventricular behaviour, it may be that a temporary gross lowering of activity acts in restarting the normal rhythm of activity in a way comparable to that in which quinidine restores normal cardiac rhythm. This comparison is capable of very extensive but as yet quite unjustifiable elaboration.

While there is evidence (Hall and Goodwin, 1938; Himwich et al., 1939) that there is a severe anoxæmia at the time of the convulsion, and that the histological changes observed may be due to this cause, it is possible that other vascular mechanisms may play a part. Gellhorn (1938) regards cerebral anoxia as the common intermediate mechanism in all forms of shock-therapy, but he suggests that its beneficial effects on schizophrenic states are due not to a depressant action on the cerebrum but to reflex stimulation of the sympathetic system.

The hearts and vessels of chronic catatronics are frequently found at autopsy to be small and hypoplastic (Lewis, 1936) and marked vascular stasis is often present in this condition. It is notable that after a few convulsions this stasis clears up, and it seems possible that the convulsion, by increasing the use of the capillary field in the brain and elsewhere, can restore the normal blood supply to these parts. This view receives support also from the work of Freeman (1934), who has demonstrated a considerable slowing of the circulation-time in schizophrenics, although others have been unable to confirm this (Finesinger, Cohen, and Thompson, 1938; Loewenhardt, Lorenz, Martin, and Malone,
1929). Angyal believes that by increasing the bloodflow in this way the brain is flushed of toxic material.

Antagonism between Schizophrenia and Epilepsy.—Although, as has been described, convulsion-therapy was founded on the observation that schizophrenics sometimes improve after the appearance of convulsions, the presence of an actual antagonism between the two conditions is far from proved. Although the work of Glaus (1931) and of Steiner and Strauss (1932), which includes observations of 12,000 cases, would suggest that epileptiform fits are of much rarer occurrence in schizophrenics than would be expected from the general incidence of the two conditions, Esser has collected observations on about 10,000 from the literature, and finds that convulsions are fairly frequent in cases of catatonia and are by no means always followed by a remission of symptoms. The subject has been reviewed frequently during recent years, and it is certainly not possible to show that the conditions are almost mutually exclusive, as was at first thought. There seems to be little support for the theory of antagonism when metabolic comparisons are made between the two conditions, but the observations of Jasper, Fitzpatrick, and Solomon on the electrical changes in the cortex (referred to above) show that in this respect there are some points of contrast. The favourable effects of convulsions in many cases of manic-depressive psychosis cannot, of course, be explained by this hypothesis, and v. Meduna himself is now inclined to agree with his critics. The criticism . . . seems to be justified as much by the results of convulsion-therapy in non-schizophrenic conditions, especially melancholia” (Meduna and Rohny, 1939).

**Summary and General Impressions**

There can be no doubt that the introduction of pharmacological shock-therapy has been the most stimulating event in the therapy of mental disorders since the discovery of the malarial treatment of general paralysis. It will be recalled how high recovery rates were recorded in the early reports on malarial therapy, and how it came to be shown that these results could only be expected when the condition had been diagnosed early, and too much permanent damage had not already been done. It will be recalled also how, when the use of this method was extended to other mental disorders, although some favourable results were recorded at first, it soon became clear that the treatment was specific for one disease. There are some similarities in the present situation with convulsion-therapy. Not only have later results shown that the early high recovery rates cannot be uniformly anticipated, but it is evident that very little can be expected when the pathological process has advanced beyond a certain point. Further, the recovery rates in some series are lower than the spontaneous remission rate in some prognostically favourable groups of schizophrenics, and this, with the high frequency of relapse, calls into question the actual usefulness of this mode of treatment. Extension of the method to other forms of mental disorder, especially manic-depressive psychosis and degenerative hysteria, has been attended with some success, and it seems
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probable that, as with prolonged narcosis, convulsion-therapy may be able to
determine a change in the individual's reaction in cases where such a change
might be expected to occur in any case.

In assessing the value of convulsion-therapy we have to face two new
difficulties. First: we have but little knowledge of the pathology of the
conditions which appear to benefit by it, nor do we know whether the con-
ditions which exhibit the schizophrenic symptom-complexes have a common
pathology; and secondly: we have no exact idea of the mode of action of
convulsions and cannot, therefore, know at what cost to the individual the
improvement is obtained. We are aware that a normal man may have malaria
without subsequent deterioration of his mental health and efficiency, but we
know that individuals who have spontaneous convulsions, with many points of
similarity with cardiazol convulsions, do tend to deteriorate, frequently very
rapidly, and that this deterioration is associated with abnormalities of memory
and psychomotor and affective changes such as have been described after
therapeutic convulsions.

Before undertaking treatment, therefore, we must realize that, if we are to
return to normal life a person who, by reason of an apparently deteriorating
mental disorder, may not be able to adapt himself to society again, we may be
doing so at the price of damaging some of the more highly developed parts of
his nervous system. Even, however, if it were certain that permanent damage
to the nervous system were inevitable, it might still be justifiable to continue.

Many cases of general paralysis who have recovered as the result of pyrexial
treatment have brains that have been severely damaged by the disease before
treatment was commenced, and yet are seemingly able to adapt themselves even
better than before their illness, possibly because the illness has removed an
inhibiting self-criticism which formerly prevented them from taking chances
with their environment. It is by no means certain that the retention of the
highest intellectual functions is consistent with the optimum adaptation to
society or with the greatest happiness.

The effects of convulsion-therapy have done much to stimulate speculation
and experiment, and have provided a link with the earlier work on temporary
remissions. They have given renewed confidence to those who hold that some
at least of the schizophrenic reactions may be reversible if they are appropriately
treated before permanent change has occurred.

It is unlikely that one mode of action alone is able to bring about the bene-
ficial effects in all cases. It is at least likely that there are psychical and somatic
components in the mechanism of recovery, a mechanism which may vary in
cases of different kinds within the schizophrenic group. If in future convul-
son-therapy has a more limited application than was at first thought, this is no
reason for its total abandonment. It is our duty to develop, as early as possi-
ble, a sense of proportion with regard to the method and to find its true place
in psychiatric treatment.
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