CONVULSION THERAPY.

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Therapeutic convulsions were introduced by Meduna (1937) in 1934. After preliminary trial with intramuscular camphorated oil, Meduna soon discovered the great advantages of intravenous cardiazol (leptazol, metrazol), which remains the best of the chemical methods of fit production. Many descriptions of the various aspects of the cardiazol fit are available (Cook, 1938*a*; Ebaugh and Shanahan, 1939; Katzenelbogen *et al.*, 1939; Strauss, Landis and Hunt, 1939; Dean, 1940; Hemphill, 1940).

Triazol (azoman, hexazol) (Walk and Mayer-Gross, 1938; Braunmühl, 1938; Wyllie, 1940), ammonium chloride (Bertolani, 1938; Dax, 1940) and picrotoxin (Low *et al.*, 1939, 1940) have also been used. Triazol can be used intramuscularly as well as intravenously, but its action is less dependable and regular than cardiazol, and it appears to be far more dangerous. Wyllie (1940) reported 4 deaths in 85 cases treated by triazol, and Nightingale and Meyer (1940) 1 death in 59 cases.

The chief drawback to most forms of chemical induction, and particularly to cardiazol, is a feeling of horror and apprehension, often quite indescribable, experienced by the patient during the few seconds between injection and unconsciousness. This causes a real dread of the treatment in many cases. Thrombosis of veins at the site of injection is another disadvantage, which sometimes prevents completion of the course, especially in plump females with small superficial veins. Thrombi formed in the injected veins may lead to pulmonary or other infarcts (Zeifert, 1939).

In 1938 Cerletti and Bini, after ensuring its safety by comprehensive animal experiments, described an electric method of administering convulsions. There are many excellent descriptions of the technique (Cerletti and Bini, 1938; Fleming *et al.*, 1939; Golla *et al.*, 1940; Shepley and McGregor, 1939, 1940; Kalinowsky and Barrera, 1940; Gonda, 1941; Androp, 1941; Hemphill and Walter, 1941; Whitsell, 1942). The electric convulsion differs from the cardiazol convulsion in that there is (1) immediate unconsciousness on applying the current, (2) absent or short latent period between unconsciousness and fit (Gonda, 1941; Goldman and Baber, 1942), and (3) reduction in time and severity of tonic and clonic phases (Shepley and McGregor, 1939, 1940; Golla *et al.*, 1940; Gonda, 1941). The total duration of the electric fit averages 35 to 50 seconds as against 35 to 75 seconds with cardiazol.

Its main advantages are (1) less unpleasant (Barnhoorn, 1940; Smith *et al.*, 1942; Shelton, 1942); (2) reduction of complications owing to milder convulsions—fractures are reduced from 22 per cent. to 5 per cent. (Smith *et*

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al., 1942) ; (3) absence of venous fibrosis and thrombus formation ; (4) simpler and quicker administration (Fleming *et al.*, 1939 ; Barnhoorn, 1940 ; Smith *et al.*, 1942) ; (5) economy (Fleming *et al.*, 1939 ; Smith *et al.*, 1942).

The freedom from severe apprehension, due to instantaneous unconsciousness and slight retrograde amnesia, and the reduction in vertebral and possibly other fractures are alone sufficient to make ECT the method of choice. As far as I can ascertain no deaths have occurred due to the electric shock itself. There would appear to be no significant difference in the results of treatment by cardiazol or other injection methods or by electric convulsions (Whitsell, 1942 ; Pacella and Barrera, 1943). "The method is technically effective, simple and safe, and arouses no fear or hostility in the patients" (Fleming *et al.*, 1939) is a very fair summary which has been amply confirmed.

Course.—The success of convulsion treatment depends to no small extent upon the adequate nature of the course. The usual spacing is three convulsions a week (Beckenstein, 1939 ; Zeifert, 1941 ; Kalinowsky and Worthing, 1943). Shelton (1942) prefers 5-day intervals to avoid temporary confusion and amnesia, but Hemphill and Walter (1941) consider three times weekly is not always enough and advocate daily convulsions in some cases, at least during the first week. Kalinowsky and Worthing (1943) obtained no better results with daily than with thrice-weekly treatments. There is no doubt that the effects of treatment are apt to wear off between fits if the interval is too long, and every other day appears to be the most favourable routine spacing.

The number of fits given is a very important consideration. In schizophrenia a much greater number is indicated than in affective states. Meduna (1937) originally stressed the need for at least 20 fits in unremitting cases of schizophrenia, and most workers advocate this minimum in the absence of good remission, with increase to 30 or more where necessary (Cook, 1938*a* ; Beckenstein, 1939 ; Ebaugh and Shanahan, 1939 ; Zeifert, 1941 ; Gonda, 1941 ; Kalinowsky and Worthing, 1943). When a good remission occurs early in treatment a further two to six fits are recommended before terminating the course (Meduna, 1937 ; Ebaugh and Shanahan, 1939 ; Zeifert, 1941 ; Kalinowsky and Worthing, 1943). Strecker *et al.* (1939) advised confining courses to ten fits with a view to avoiding cardiac damage, but this cannot be recommended if good results are to be obtained. Gonda (1941) and Impastato and Almansi (1942) believe that many workers have condemned convulsion treatment in schizophrenia because they have ended treatment too soon. The importance of giving adequate courses, convincingly shown by Zeifert (1941) and Kalinowsky and Worthing (1943), cannot be too strongly emphasized.

It is one of the peculiarities of convulsion treatment that relapses often occur within three or four weeks of an apparent good remission. These relapses can usually be aborted by immediately giving a short subsidiary course. For this reason Zeifert (1941) advocates keeping the patient under observation for four to six weeks after the end of treatment. Most workers will allow four weeks to be sufficient. Doubtless many of the relapses that mar the results of convulsion therapy in schizophrenia are due to too early release. Reznikoff (1940) considers there is a definite persistent tendency to relapse, and

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Ebaugh and Shanahan (1939) found 38 per cent. relapses after 1 to 17 months. Cohen (1939*a*), however, noted that 89 per cent. patients who had achieved a full remission remained well six months after treatment, and Kalinowsky and Worthing (1943) state, "Once a full remission is obtained, relapses in schizophrenics after ECT do not seem to be more frequent than after insulin treatment."

In affective states an average of less than ten fits is usually effective (Bennett, 1938, 1939; R. H. and G. A. Young, 1939; Gonda, 1941; Closson and Swaney, 1941; Kalinowsky and Worthing, 1943). Zeifert (1941) found 12 to 20 fits necessary in involutional psychoses, and Fitzgerald (1943) gave an average of 17 fits in 150 undifferentiated depressives. The same tendency to relapse within a few weeks of treatment is seen in affective as in schizophrenic states, with the same consequent necessity for keeping patients under observation for at least four weeks, if possible.

Subconvulsions.—It is natural to wish to avoid the somewhat barbarous complication of the major fit, and this desire has been encouraged by the minor and transient symptomatic improvements not uncommonly seen after one or two subconvulsive doses of cardiazol or ECT at the beginning of a course. Unfortunately subconvulsive treatment has proved to be disappointing (Furst and Stouffer, 1941; Flescher, 1942; Impastato and Almansi, 1942). Kalinowsky *et al.* (1942), treating 27 patients of various types with courses of subconvulsive ECT, obtained no recoveries and only 5 improvements. Subsequently 22 of these patients were given full convulsions with 7 recoveries and 9 improvements. Cohen (1939*b*) treated 19 patients with subconvulsive doses of cardiazol; 16 were unimproved, and of the three who improved two had two or more accidental convulsions. Later the 16 unimproved cases were given full convulsions with 2 recoveries and 5 great improvements. It is noteworthy that in cases reported as improved after subconvulsive courses accidental major fits have often occurred. Androp (1941) found subconvulsive doses, although less effective than convulsions, sufficiently encouraging to warrant further trial, and Young (1941) reported full recovery in one case of acute confusional hallucinatory reaction after nine phrenazol subconvulsive doses.

It is well known that patients often become more agitated and apprehensive after subconvulsive doses of cardiazol (Cottington and Gavigan, 1939), and E., E. S-. and L. Ziskind (1942) firmly believe subconvulsive doses predispose to therapeutic failure in proportion to the number of such doses.

Softening of fits.—In order to avoid traumatic and other complications and diminish the risk in treating elderly or infirm patients, convulsions may be modified or softened by means of curare, β-erythroidin hydrochloride, quinine methochloride, magnesium sulphate or spinal anaesthesia.

The curare modification is fully described by Bennett (1941) and Gray *et al.* (1941). Curare acts on the motor end-plates, inhibiting the action of acetylcholine. The average dose is 5–12 c.c. (1 c.c. for each 20 lb. body weight) of an aqueous solution, in which 1 c.c. contains 10 mgm. of the active principle, injected intravenously over a period of one to two minutes (Bennett, 1941) or half to one minute (Gray *et al.*, 1941). General muscular weakness results,

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reaching its peak about two minutes after the end of the injection (Bennett, 1941). The effect vanishes in 15 to 20 minutes, and the convulsion should be induced within three minutes of the end of the curare injection (Bennett, 1941; Gray *et al.*, 1941). The resulting fit is typical, but greatly softened, the usual violent clonic spasm being especially reduced. Paresis of respiratory muscles may lead to respiratory depression or failure requiring artificial respiration and the injection of prostigmin (Gray *et al.*, 1941; Woolley *et al.*, 1942). Three out of 50 cases reported by Gray *et al.* (1941) required these remedies. Charlton *et al.* (1942) reported a death from respiratory failure during curare-metrazol treatment.

The use of curare with ECT is said to be more dangerous than with cardiazol, because whereas cardiazol acts as a respiratory stimulant electro-convulsions tend to depress respiration (Worthing and Kalinowsky, 1942); Bellet *et al.* (1941) noted a serious form of arrhythmia following this combination. Cash (1942), however, claims to have used curare with ECT in 139 cases without mishap, and others recommend the combination (Furst and Stouffer, 1941; Woolley *et al.*, 1942; Shelton, 1942).

The efficacy of convulsion therapy appears to be in no way diminished by the softening of the fits (Bennett, 1941; Gray *et al.*, 1941; Harris *et al.*, 1941). Bennett (1941) found no material difference in the results of treating 99 patients suffering from affective psychoses with cardiazol alone and 64 comparable patients with curare-modified fits. This is a little surprising considering the unsatisfactory effect of subconvulsive treatment. The EEG after treatment is said to be the same as with cardiazol alone (Harris *et al.*, 1941; Bennett, 1941). There would appear to be some difficulty in ensuring that the fit occurs during the peak of curare activity, and injuries sustained during curare-modified fits have been attributed to timing errors (Bennett, 1941; Woolley *et al.*, 1942).

Quinine methochloride, β-erythroidin hydrochloride and magnesium sulphate all modify the convulsion similarly to curare. The β-erythroidin-metrazol combination is fully discussed and advocated by Rosen *et al.* (1940), but Williams (1941) gives a warning that β-erythroidin has definite toxic properties and that some individuals show marked cardiac susceptibility to it. Cottington (1941) has used this modification on children.

Quinine methochloride (Bennett and Cash, 1941) is a synthetic compound with a curare-like action. Its dosage is said to be more accurate and easily gauged than that of curare, but it provokes severer respiratory complications.

Magnesium sulphate (Yaskin, 1941) is given intravenously in a dosage of 25 to 30 c.c. of a 25 per cent. aqueous solution. Its effects pass off within ten minutes. Calcium chloride (10 per cent. aqueous solution) is recommended as an antidote (Yaskin, 1941). A case of sudden death immediately after the injection of 30 c.c. of magnesium sulphate solution has been reported (Rosenbaum and Lipton, 1942).

Spinal anaesthesia (Hamsa and Bennett, 1939; H. J. and L. M. Shorvon, 1943) has been employed to prevent injuries to the spine and lower part of the body. Its main use would appear to be in cases of pre-existing vertebral, hip or femoral disease or injury.

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All these modifications add a complication to therapy and have their own dangers. None of them can be unreservedly recommended for general use, but they may prove valuable in individual cases embodying special risks.

Various methods have been employed to eliminate or allay the feeling of dread associated with the cardiazol injection; these include general anaesthesia (Neustatter and Freeman, 1939; Fabing, 1942), insulin coma (Russell, 1938; Sands, 1939; Notkin *et al.*, 1943), hyoscine and morphine (Cook, 1938*a*), hyoscine alone (Edlin and Klein, 1940). Neither hyoscine nor morphine increase the convulsion threshold. These methods have been almost entirely obviated by the advent of ECT, but the occasional severely agitated, negativistic patient, who becomes terrified when approached for any treatment, may be saved much unnecessary suffering by an injection of morphine, gr. $\frac{1}{4}$–$\frac{1}{2}$, with hyoscine, gr. $\frac{1}{100}$–$\frac{1}{50}$, half an hour before treatment.

Dangers and Complications.

Deaths.—As regards cardiazol, Meduna and Friedman (1939), investigating 3,046 cases, found nine deaths (0·29 per cent.), and Kolb and Vogel's survey (1942) disclosed a death-rate of only 0·1 per cent. in more than 36,000 cases. Kinsey (1941), as a result of a nation-wide questionnaire (U.S.A. and Canada), as well as of collecting from the literature, reported 43 deaths associated with cardiazol treatment of 18,543 cases (0·23 per cent.). They concluded that six of these were apparently not caused by the treatment and 31 "not directly" due to treatment; 27 deaths followed pulmonary complications, including 12 from tuberculosis, and 9 were due to cardiac causes. When it is considered that all deaths occurring in association with treatment were included, it appears probable that less than two deaths per 1,000 cases were actually initiated by cardiazol fits. As far as can be assessed ECT is considerably safer. Impastato and Almansi (1942) could only find records of two deaths from ECT, and Kolb and Vogel (1942) four deaths in 7,207 cases.

Complications.—Excluding injuries produced in the fit, pulmonary complications are the most frequent and most serious. There is a definite danger of activating latent tuberculosis (Pameijer, 1938; Harris and Birnie, 1938; Steinberg and Nierenberg, 1939; Kraus and Viersma, 1940; Read, 1940; Colomb and Wadsworth, 1941; Furst and Stouffer, 1941). Bulley and Greene (1941) found tuberculosis in 8·3 per cent. of 277 schizophrenics over a period of three years after treatment, as against 3 per cent. in a comparable group of untreated schizophrenics. In nine of these cases the trouble started acutely within four months of the end of treatment. Chest fluoroscopy or radiography before treatment is recommended (Harris and Birnie, 1938; Blair, 1940*a*; Bulley and Greene, 1941). With care in selecting cases, thorough history investigation and complete physical examination, few cases of latent tuberculosis should be missed, and the tuberculosis activation rate of little more than 1 per 1,000, obtained by Kolb and Vogel (1942) from U.S. and Canadian figures, should not be exceeded. Lung abscesses (Pameijer, 1938; Beckenstein, 1939; Ross, 1939; Notkin *et al.* 1940) are found in about 0·1 per cent. of cases (Meduna and Friedman, 1939). They may be due to aspiration during or immediately after the fit or, in the case of intravenously induced fits, to

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mobilization of a thrombus at the site of injection (Zeifert, 1939). Pneumonia, both lobar (Ross, 1939) and aspiration (Novotny, 1939), is prone to occur. Lung abscesses and infarcts and aspiration pneumonia are often attributed to dental sepsis, and preliminary dental examination is essential.

Cardiovascular accidents are rarely associated with induced fits; Meduna and Friedman (1939) recorded acute myocardial collapse in only 0·06 per cent. cases. Transient ECG changes may occur after fits, probably due to cardiac anoxaemia (Good, 1940*a*; Levine *et al.*, 1940) or vagal irritation (Hoffmann *et al.*, 1940; Wender and Jezer, 1941). It is generally agreed, however, that reasonably healthy hearts incur no permanent damage (Good, 1940*a*; Messenger and Moros, 1940; Wender and Jezer, 1941), although Read (1940) found ECG changes in 5 out of 320 cases a year or more after treatment. Many patients with more or less severe cardiovascular disease have been successfully treated with both cardiazol and electric fits (Borgarello, 1939 [ECT]; Myerson *et al.*, 1941 [ECT]; Robinson and Shelton, 1940 [cardiazol]; E., E. S-. and L. Ziskind, 1942 [cardiazol]). Robinson and Shelton (1940) administered five cardiazol fits to a woman, aged 84, suffering from diffuse myocarditis, and six cardiazol fits to a man, aged 75, with cardiovascular degeneration; both are said to have recovered uneventfully. As regards choice of treatment in association with cardiovascular disease, cardiazol is a cardiac stimulant, but tends to produce stronger fits, while electro-fits tend to depress the cardiac system, but according to Jessner and Ryan (1942) the degree and frequency of cardiac complications are much less, because the fit is less violent. Several cardiac deaths have been reported (Pameijer, 1938; Hayman and Brody, 1939; Michael and Wittenbrook, 1940; Impastato and Almansi, 1942). Obviously each case must be treated individually; the severity of the mental condition and its suitability for other forms of treatment, especially leucotomy, as well as the physical state, must be considered. E., E. S-. and L. Ziskind (1942) give examples of patients, particularly involutional melancholics, deprived of convulsion treatment owing to cardiovascular or other physical disease, who have committed suicide or died of exhaustion, and consider "contra-indications based on physical disabilities may be over-emphasized." Smith *et al.* (1942) and Impastato and Almansi (1942) have reported "alarming apnoea" after electrically produced fits, but no untoward results have ensued.

Belated fits some minutes or even hours after the injection occasionally occur with cardiazol, probably due to some of the fluid finding its way outside the vein and exerting its influence later. *Status epilepticus* has been reported after cardiazol injections (Beckenstein, 1939; Becker and Stein, 1940; Zeifert, 1941) and one hour after an electro-shock (Bellet *et al.* 1941), but can easily be controlled by intravenous luminal or sodium amytal, and is not a serious or common complication.

Spontaneous epileptic fits starting some time after a course of convulsions are by no means uncommon (Read, 1940; Liebert, 1942). Pacella and Barrera (1942) found no case of spontaneous epilepsy in patients with normal pre-treatment EEG, but one patient with a suspicious EEG had a spontaneous fit four weeks after his course of ECT; they noted also that six epileptics, who were each given one electro-fit, suffered more *grand* and *petit mals* than

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usual during the following few days. Fortunately this epileptic tendency can be cut off with the ordinary anti-convulsants, and there does not appear at present to be any real danger of creating epileptics by the treatment.

The danger of producing permanent brain lesions such as occur in chronic epileptics has stimulated much animal experimentation with cardiazol and electric fits. This, together with the findings in human brains, is fully dealt with in the chapter on neuropathology.

No constant changes are seen either in animals or humans. When the animal is killed soon after one or a series of fits, widespread subarachnoid haemorrhages and punctate haemorrhages of the brain substance may be found (Alpers and Hughes, 1942; Heilbrunn and Weil, 1942). At a later stage mild ischaemic and glial reactions with occasional neurone damage are described. There is some evidence that the amount of damage has some relation to the quantity of cardiazol injected (Weil and Liebert, 1938) and to the total duration of convulsions (Strecker *et al.*, 1939; Cleckley, Bowles and Mettler, 1940). Many animals appear to escape damage even after multiple convulsions (Winkelman and Moore, 1940; Heilbrunn and Weil, 1942; Neumann *et al.*, 1942). It is noteworthy that monkeys, whose CNS approaches most nearly to that of man, show the least damage. Arieti (1941) found no lesions in two monkeys and hardly perceptible or very mild degenerative cell changes in three others. Strecker *et al.* (1939), examining the brains of seven monkeys which had received 67 to 147 minutes of convulsions, found no changes in three and mild cellular changes and subarachnoid haemorrhages in four. Finley and Brenner (1941) described small cortical foci, in which there were missing neurones and vascular damage, and scattered cortical areas showing glial cell proliferation and hypertrophy.

As regards human material, Weil and Liebert (1940), examining the brains of six patients who died two to ten months after cardiazol treatment, found hypertrophy and hyperplasia of astrocytes and to a lesser degree of microgliocytes. Whitehead *et al.* (1940) found scattered neurone damage and slight glial reactions in two cardiazol-treated cases, and Petersen (1939) generalized ischaemia of ganglion cells and diffuse gliosis also in two cardiazol cases. Mild glial changes of the type seen in epilepsy were noted in two cases examined by Meyer (1939). Glial reactions are the most frequent findings, but appear to be neither severe nor important.

Transient electroencephalographic changes normally accompany induced fits (Cook and Walter, 1938; Davis and Sulzbach, 1940). More persistent changes have been described; these usually clear up within three or four weeks (Polatin *et al.*, 1940; Hughes *et al.*, 1941; Impastato and Almansi, 1942; Levy *et al.*, 1942), but in isolated cases may still persist after six months (Pacella *et al.*, 1942) or a year (Davis and Sulzbach, 1940). This subject is fully treated in the chapter on electroencephalography.

A state of amnesia, varying from a mild tendency to forget names to severe confusion of the Korsakow's type, is often seen during and for a short time after a course of convulsions (Platner, 1938; Ziskind, 1941; Hemphill and Walter, 1941; Furst and Stouffer, 1941; Levy *et al.*, 1942; Smith *et al.*, 1942; Impastato and Almansi, 1942; Kalinowsky and Worthing, 1943). It may

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follow a single fit or be absent during an extensive course. There is some evidence that it can be correlated with abnormal EEG changes and that both tend to clear up together (Polatin *et al.*, 1940). Ziskind (1941) considers this condition undesirable and possibly harmful, and Dynes (1939) believes gross deterioration sometimes ensues. Some workers stop the course when it occurs, but the majority consider it no contra-indication to further treatment, and a few believe it may be of good prognostic significance (Shapiro and Freeman, 1939; Impastato and Almansi, 1942).

It is unusual for any appreciable defect to remain after a few weeks (Kalinowsky *et al.*, 1941; Hemphill and Walter, 1941; Levy *et al.* 1942; Impastato and Almansi, 1942), but occasionally recovery is not complete for several months (Furst and Stouffer, 1941; Ziskind, 1941; Smith *et al.*, 1942). Memory tests have produced conflicting reports. Tooth and Blackburn (1939) found memory defect still present six months after treatment in 5 out of 16 cases, while Sherman *et al.* (1941) could find no significant changes in 10 psychotics tested before, during and after treatment. Reports of memory disturbance lasting many months are very occasional, and at present there is little evidence that permanent intellectual defect is a practical danger.

Other neurological sequelae after induced convulsions are conspicuously absent.

Skeletal Complications.

Spine.—Because vertebral fractures are largely symptomless and only discoverable by radiography, they were not described until four years after the inception of convulsion therapy. Following the reports of single cases by Wespi (1938) and Stalker (1938) routine radiography of the spine soon revealed an alarming proportion of these fractures, and for a time the future of convulsion treatment was in serious jeopardy. Fortunately they are not followed by serious sequelae and have proved to be far less important than was at first feared.

The predominant lesion is a compression of one or more vertebral bodies (as many as five have been fractured in the same patient, Graves and Pignataro, 1940; Easton and Sommers, 1942), varying from slight deformity of the anterior margin to complete crushing of the whole body. Other less frequent and striking lesions are herniation of the nucleus pulposus of the intervertebral disc into neighbouring vertebrae, *knörpelnötchen*, etc. Fractures usually occur during one of the first few convulsions.

Incidence.—Polatin *et al.* (1939) found an incidence of 43·1 per cent., but later reports have tended to be far less alarming. An analysis of 16 papers dealing with cardiazol fits yields the much lower figures of 289 cases of fracture in 1,344 patients (21·5 per cent.). The reduction is probably due to added care in preventing fractures during fits and possibly to the elimination of old lesions by taking radiograms before as well as after treatment. The incidence in ECT appears to be very much lower, figures from five sources (Golla *et al.*, 1940; Furst and Stouffer, 1941; Smith *et al.*, 1942; Worthing and Kalinowsky, 1942; Barrett *et al.*, 1942) totalling 14 fractures in 371 patients (3·9 per cent.).

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Compression fractures also occur in patients subject to spontaneous major epileptic fits. Figures collected from nine sources show 64 cases of spinal fracture out of 381 patients (16·8 per cent.). The proportion is not much below that of cardiazol fractures. In a radiological survey of 143 consecutive cases treated with convulsions, 134 epileptics suffering from long-standing major fits and 135 controls, Cook and Sands (1941) found 14·7 per cent. cases of vertebral fracture in the treated group, 10·4 per cent. in the epileptics and 1·5 per cent. in the control group. A higher percentage for both groups (31·4 per cent. with induced fits, 34·2 per cent. in epileptics) was reported by Reed and Dancey (1940). Worthing and Kalinowsky (1942), however, reported no fractures in 60 patients undergoing ECT and only one in 42 epileptics. The discrepancies in these reports, more particularly as regards epilepsy, where incidence cannot be affected by therapeutic technique or prophylactic measures, show all too convincingly that radiological diagnosis of vertebral fractures is by no means an exact science.

Induced convulsion fractures mainly involve the mid-dorsal region (Graves and Pignataro, 1940; Krause and Langsam, 1941; Cook and Sands, 1941; Barrett *et al.* 1942; Easton and Sommers, 1942). Those associated with epilepsy are generally found in the lower thoracic and upper lumbar region (E. and E. S-. Ziskind, 1939; Cook and Sands, 1941). Barrett *et al.* (1942), however, noted a fairly even distribution from Thor. III to Thor XII in nine cases involving 19 vertebrae.

In view of this difference in distribution no absolute conclusion can be drawn from the absence of referable symptoms in long-standing epilepsy, but it is reassuring that neither Kümmel's disease nor spinal cord involvement occur as a result of epileptic fits.

The mid-dorsal fractures complicating induced fits are much more closely akin in distribution and nature to those associated with tetanus. They may be brought about by the abrupt flexion spasm, which often initiates both cardiazol and tetanic convulsions and which is less frequent in electro-convulsions and usually absent in epileptic fits. Worthing and Kalinowsky (1942) attribute the injuries to the short pre-convulsive "first clonic phase" seen in cardiazol fits (Strauss *et al.*, 1939) and also in tetanic seizures. Strauss *et al.* (1939) analysed the cardiazol fit by means of high-speed motion pictures, and pointed out that this first clonic phase is predominantly flexor, whereas in the second (main) clonic phase extension prevails. Dedichen (1939) believes that the severity of the tonic phase in cardiazol fits is the decisive factor. Most workers consider the fractures occur in flexion, but Tureen and Key (1940) believe they are produced during opisthotonos and are due to severe longitudinal compression of the spine; in their view the anterior part of the mid-dorsal vertebrae suffers most because even in opisthotonos the normal mid-dorsal curve persists. This explanation of the vulnerability of the anterior part of the body in the mid-thoracic region cannot be correlated with the fact that, when convulsion fractures do occur in the lumbar region, anterior wedging is equally characteristic. Furst (1940) has shown experimentally that much less force is required to crush the anterior-superior margin of the fifth thoracic vertebra than any other part of its body, possibly due to the construction of

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TABLE I.—*Vertebral Fractures Due to Convulsions.*

Induced fits.	Thor. II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	Lumb. I.	II.	III.	IV.	Total Vertebrae	Cases.
Stalker (1938)	–	–	–	–	1	1	–	–	–	–	–	–	–	–	–	2	1
Wespi (1938)	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	1	1
Graves and Pignataro (1940)	2	–	3	4	6	4	1	–	–	–	–	–	–	–	–	20	15
Cook and Sands (1941)	–	–	1	7	6	4	3	4	1	–	–	1	–	–	–	27	21
Krause and Langsam (1941)	–	–	11	17	15	12	6	3	2	1	1	1	1	–	–	70	32
Easton and Sommers (1942)	–	3	25	33	24	17	4	3	2	–	–	–	–	–	–	111	46
Barrett *et al.* (1942)	–	2	6	2	7	5	2	–	–	–	–	–	–	–	–	24	12
Total	2	5	46	63	59	44	16	10	5	1	1	2	1	–	–	255	128
Epilepsy.																	
E. & E. S-. Ziskind (1939)	–	–	–	–	–	–	–	–	1	1	1	–	1	1	–	5	3
Blair (1940*b*)	–	–	–	1	1	–	–	–	–	–	–	–	–	–	–	2	1
Cook and Sands (1941)	–	–	–	–	–	4	1	–	2	–	3	3	3	1	1	18	14
Worthing and Kalinowsky (1942)	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	1	1
Barrett *et al.* (1942)	–	2	2	2	2	4	2	2	1	1	1	–	–	–	–	19	9
Total	–	2	2	3	3	8	3	2	4	2	5	4	4	2	1	45	28

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its trabeculae. Easton and Sommers (1942) attribute the mid-dorsal localization to the fact that the extensor muscles are weaker and the intervertebral discs thinner in this region than elsewhere.

Symptoms.—The fractures are mostly symptomless and only revealed by routine lateral radiograms of the spine. These should be taken before as well as after treatment (Cook and Sands, 1941; Androp, 1941; Easton and Sommers, 1942; Impastato and Almansi, 1942) in order to eliminate old or doubtful lesions. Pain in the back and local tenderness are sometimes experienced (Bennett and Fitzpatrick, 1939; Wyllie, 1940; Graves and Pignataro, 1940; Easton and Sommers, 1942), but the degree of pain has little relation to the severity of the lesion (Polatin *et al.*, 1939; Cook and Sands, 1941).

Backache after convulsions is often of muscular origin and does not necessarily indicate vertebral injury (Cook and Sands, 1941). Referred pain has been reported in a small number of cases (Cook and Sands, 1941; Easton and Sommers, 1942), but usually clears up in a few weeks. Slight gibbus may follow severe crushes, and discomfort lasting many months has been reported in one case (Androp *et al.*, 1941), but few patients appear to be seriously inconvenienced (Jessner and Ryan, 1942). In spite of the many thousands of convulsion courses given no serious permanent disability has been reported. This is all the more reassuring as delayed vertebral collapse (Kümmel's disease) tends to occur during the first year after injury.

Only when pain is intense or the lesion sufficiently severe to suggest the possibility of subsequent kyphus does treatment appear to be necessary; in such cases a plaster jacket or brace is usually applied. It is generally agreed that mild or symptomless fractures, revealed by radiography, do not preclude further fits. Some workers (Krause and Langsam, 1941; Easton and Sommers, 1942) do not regard kyphosis, scoliosis or herniation of the nucleus pulposus as contra-indications, but severe spinal distortions obviously afford some risk of cord injury. Vertebral fractures would appear to be more prevalent in the elderly and those with long-standing illness (Meduna and Friedman, 1939; Graves and Pignataro, 1940), but Hemphill and Walter (1941) believe fit and muscular subjects are a greater risk; evidently they consider muscular strength a more important factor in producing spinal fractures than bony weakness. Osteoporosis is usually considered a definite contra-indication (Krause and Langsam, 1941; Easton and Sommers, 1942). Evans (1941, 1942), however, relates the astonishing case of an agitated melancholic suffering from generalized osteoporosis and marked dorsal kyphosis, who, all other treatments having failed, was subjected to cardiazol convulsions. Despite the occurrence of a fracture of the neck of the humerus during the third fit, six more convulsions were eventually administered without further incident; the mental symptoms disappeared.

Prevention.—Of the various measures taken to prevent these fractures hyperextension of the trunk on a hard couch or table with a pillow or sandbags under the mid-dorsal region and counter pressure on shoulders and hips (Cheney *et al.*, 1941*a*; Worthing and Kalinowsky, 1942; Easton and Sommers, 1942) appears to be the most popular; additional immobilization of arms and legs is practised by some (Dedichen, 1939; Furst, 1940; Moore and Winkelman,

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1941), but may increase the risk of the much more serious accidents of long bone fractures. Furst (1940) claims to have reduced the incidence of cardiazol vertebral fractures to 8 per cent. by his extension method of complete immobilization.

More heroic measures are recommended by others. Curare has been used successfully with cardiazol (Bennett, 1941; Gray *et al.*, 1941; Harris *et al.*, 1941; Woolley *et al.*, 1942) and with ECT (Cash, 1942; Shelton, 1942; Woolley *et al.*, 1942), while other fit-softening modifications (*q.v.*) have their advocates. They are doubtless able to reduce the risk of vertebral fractures to a minimum, but add a complication of some danger and should be reserved for cases involving high fracture risk.

It is now generally felt that the possibility of vertebral injuries should in no way preclude convulsion treatment. With the advent of ECT the incidence has been very much reduced, while added safeguards are immobilization of the spine in hyperextension and, in bad fracture risks, preliminary curarization or spinal anaesthesia. Worthing and Kalinowsky (1942) echo the general opinion in stating that vertebral fractures are largely preventable and if they do occur have no clinical importance.

Other bone injuries.—Fractures or fracture dislocations of long bones, although less common than vertebral injuries, are far more serious. Incidence is not easy to assess because of the tendency to publish such serious injuries as a warning to others immediately they occur or without reference to the number of cases treated. Table II shows the main fractures from ten sources, each dealing with at least 100 cases.

TABLE II.—*Skeletal Fractures (Excluding Vertebrae).*

Cardiazol.	Cases.	Femur.	Humerus.	Pelvis.	Scapula.	Jaw.	Radius.	Total.
Pameijer (1938)	1,200	5	3	–	3	1	–	12
Pollock (1939)	1,140	5	2	–	–	1	–	8
Beckenstein (1939)	232	2	–	–	–	–	–	2
Kwalwasser (1940)	425	2	1	–	–	–	–	3
Reznikoff (1940)	100	–	–	–	1	–	–	1
Notkin *et al.* (1940)	100	–	1	–	–	–	–	1
Zeifert (1941)	372	2	1	–	1	–	1	5
Cheney *et al.* (1941*a*)	112	–	–	–	–	–	–	0
Total	3,681	16 (·43%)	8 (·22%)	–	5	2	1	32 (·87%)
ECT.								
Furst and Stouffer (1942)	250	–	–	1	–	–	–	1
Smith *et al.* (1942)	156	–	2	–	1	–	–	3
Total	406	–	2	1	1	–	–	4
Full total	4,087	16 (·39%)	10 (·24%)	1	6	2	1	36 (·88%)

Fracture of the neck of the femur is the most frequent and serious injury and is not uncommonly bilateral (Pameijer, 1938; Walk and Mayer-Gross, 1938; Somers and Richardson, 1939; Cummins, 1940; Krause and Scherb, 1941; Androp and Green, 1941). Deaths following this complication have

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been reported by Beckenstein (1939) and Bellenger (1939). Pelvic fractures, usually through the acetabulum, are very much rarer (Nyberg, 1938; Hamsa and Bennett, 1939; Furst and Stouffer, 1942; E., E. S-. and L. Ziskind, 1942). Fractures of the humerus are often associated with dislocation of the shoulder. Zeifert (1941) mentions a fracture of the head of the radius. Mandibular fracture (Pameijer, 1938; Pollock, 1939; Carp, 1939) is undoubtedly rare, although symptomless dislocations are numerous. Simple shoulder dislocations can usually be reduced quite easily before the patient regains consciousness and can subsequently be prevented by appropriate restraint. It will be seen that all fractures are rare, those of the femur (0·39 per cent.) and the humerus (0·24 per cent.) being the commonest. The proportion of all fractures (0·88 per cent.) is comparable to Meduna and Friedman's figure of 1·1 per cent. in over 3,000 cases for all mechanical complications exclusive of temporo-mandibular dislocation. Neither collection includes vertebral fractures.

Meduna and Friedman (1939) believe that emaciated and long-bedridden patients are particularly susceptible to long bone fractures because of an avitaminosis affecting calcium metabolism. There appears to be considerably less risk of fracture with ECT than with cardiazol (Smith *et al.*, 1942).

Prophylactic measures vary from total immobilization of the legs in extension and arms in flexion and adduction across the chest (Furst and Stouffer, 1941) to complete absence of restraint. Zeifert (1941) attributes some long bone fractures to restraining the limbs.

Curarization and other fit-softening modifications almost entirely eliminate the risk of fracture, as does spinal anaesthesia for the lower part of the body, but cannot as yet be recommended for routine usage.

Contra-indications.

The more important contra-indications have been discussed in the preceding section. Androp (1941) gives the following list: acute infections and febrile diseases; advanced heart and kidney diseases; bone atrophy in long bedridden patients; pronounced spinal curvature and osteoarthritis; severe thyrotoxicosis; malignancy; thrombophlebitis; advanced general arteriosclerosis. Gonda (1941) also gives the first five of these conditions. Hemphill and Walter (1941) advise against giving ECT during vaccine therapy or in the presence of organic CNS disturbance. The latter should not be considered an absolute bar, as states of depression associated with chronic epidemic encephalitis have responded excellently and without mishap to convulsion treatment. The most important absolute contra-indication is tuberculosis, even if only latent. Menstruation is not generally considered a bar (Gonda, 1941; Impastato and Almansi, 1942).

There is some controversy as to the advisability of giving convulsions in out-patient clinics, private homes, etc. As regards cardiazol fits the practice is generally condemned, and Bennett (1939) considers they should be given "only in well-equipped psychiatric departments by experienced psychiatrists and psychiatric nurses." Kalinowsky and Barrera (1940) also think cardiazol

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convulsions inadvisable for out-patients, but recommend ECT. ECT, with its freedom from distress and less severe sequelae, is obviously the less objectionable method and has a number of advocates (Strauss and MacPhail, 1940; Hemphill and Walter, 1941; Myerson *et al.*, 1941; Impastato and Almansi, 1942). Mayer-Gross (1941), however, has pointed out that late fits have occurred and that states of confusion and aggressiveness and exacerbations of manic and depressive episodes are not rare, even after electrically-induced fits. Perhaps the most important drawback to out-patient convulsion treatment is the difficulty in getting patients to return for further treatments when once they begin to feel better.

There are undoubtedly many patients, particularly mild depressives, preeminently suitable for convulsion therapy, who will not agree to become in-patients, and it is obviously wrong that they should be debarred from treatment if some compromise can be effected. It is perhaps fair to say that ambulatory ECT should only be administered where the patient can remain under skilled observation for several hours after treatment and can be kept in hospital overnight, if any emergency warrants this course. The importance of completing a definite course of treatment should be continually and forcibly impressed upon the patient.

Theories of Action.

Meduna's original theory of a biological antagonism between epilepsy and schizophrenia has long been discarded, but no fully satisfactory explanation of the therapeutic mechanism of convulsion treatment has taken its place. There is, however, overwhelming evidence that the major fit itself provides the main therapeutic force. Hypotheses may conveniently be divided into psychogenic and physiogenic.

Psychogenic theories.—In the early days of cardiazol convulsions, when the severe apprehension and horror of many of the patients was perhaps the most striking single characteristic of the convulsion episode, all therapeutic benefit was not unnaturally attributed by the psychogenetically minded to the emotional shock produced by the pre-convulsive aura (Humbert and Friedmann, 1938; Meier, 1938; Lipschutz *et al.*, 1939; Good, 1940*b*). Experimental and statistical work on the therapeutic effect of the fear reaction soon showed that it played no important part (Low *et al.*, 1938; Cohen, 1939*b*; Cook, 1940). The altogether poorer effects of subconvulsive doses (Furst and Stouffer, 1941; Flescher, 1942; Impastato and Almansi, 1942), which certainly produce a longer and more severe period of unpleasantness, and finally the advent of ECT, with its instantaneous unconsciousness without any aura, have conclusively invalidated this hypothesis.

More tenable psychogenic theories depend upon an identification of the sudden unconsciousness with death and upon the effect of the "rebirth" on the psyche. Schilder (1939) points out the friendliness of patients in the post-convulsion state, even when still confused; the previous libido-fixations have lost their importance and there is renewed interest in the persons next to the patient. He believes the hypomanic elation which so often follows the epileptic attack is the joy of rebirth. Hemphill (1940) suggests that the period

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of dependence after the fit tends to lead to a breaking of the psychotic withdrawal from society. He also points out that the epileptic experiences his personality as a whole, even to an exaggerated extent, while the schizophrenic's personality is split up, and suggests that the fit may help to integrate the personality. Flescher (1942) rejects the fear *motif* because (1) electrically produced *petit mals* give poorer results than convulsions, although the patient suffers the same pre-unconsciousness experiences, and (2) he has observed suicidal depressives abandoning their suicidal tendencies after a few fits. The death threat, he notes, could scarcely heal the self-destructive tendencies in these cases. He formulates an interpretation based on Freud's theory that melancholy after the loss of a dearly loved person depends on a strong ambivalent attitude towards that person. The lost object is identified with the ego, and aggressiveness, previously unconscious, is directed against it in the form of self-depreciation, self-destructiveness, guilt feelings, etc. The fit, he maintains, by its severe motor manifestations " discharges " large amounts of energy inherent in the destructive and death drives and unloads them in an individually and socially harmless manner. Postulating life as an eternal struggle between Eros and Thanatos, he considers the " discharging function " of convulsion therapy as a precious support for Eros. Glueck (1942) believes the sedative effect of the physically induced oblivion is of great importance in the psychodynamics of the patients' recovery.

Most of these psychogenic theories attribute the therapeutic benefit to the unconsciousness rather than the convulsion. If this were true any method of producing rapid unconsciousness should prove equally effective. But it is well known that amytal, evipan and other coma-producing drugs are far less effective than convulsions.

Some regard convulsions as merely adjuvant to psychotherapy and more general treatment by virtue of their effect of rendering patients more accessible. Cheney *et al.* (1941*a*) believe that symptoms only are alleviated, without materially affecting underlying pathological processes and that convulsion therapy is useful only in so far as it facilitates the total psychotherapeutic effort. Rapid, complete and seemingly permanent recoveries, however, have unquestionably been effected by induced convulsions in circumstances where psychotherapy could play no part. This in no way detracts from the obvious importance, stressed by many experienced workers (Meduna, 1937; Humbert and Friedemann, 1938; Cummins, 1940; Androp and Green, 1941; Gonda, 1941), of explanation, re-education and, where necessary, more intensive psychotherapy during the improvement process.

Physiogenic theories.—Many of the physiogenic views propounded are highly speculative and need but brief mention. Among these are: alteration of cerebral water balance (Wilmanns, 1938), irritation of the cell membrane, stimulating cell permeability (Georgi, quoted by Müller, 1939). Meduna and Friedman (1939) have suggested that metrazol directly irritates the medulla, with resultant respiratory, vasomotor and autonomic reactions, but this theory does not appear to take into account the convulsion, which Meduna previously stressed as the essential factor. Tillim and Squires (1942) consider improvement is probably the result of improved general physiological functioning and

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not through direct action on the brain. Some consider convulsion therapy acts by stimulating the mid-brain vegetative centres and autonomic nervous system (Pfister, 1938; Ewald, quoted by Müller, 1939; Hoffman, 1942). Gellhorn (1938) believes that schizophrenia involves hypofunction of the sympathetic division of the autonomic system, and that metrazol fits exert their effects by stimulating this division. But, as Himwich has pointed out, adrenalin and other sympatheticotonic drugs are useless in the treatment of schizophrenia. Angyal (1937) has suggested that the results are achieved by stimulation of diseased ganglion cells by hyperaemia following ischaemia, possibly through flushing the brain of toxins.

More important theories are concerned with anoxaemia. That marked anoxaemia does occur in convulsions has been amply proved by Himwich and his co-workers, who have shown that during cardiazol fits the oxygen saturation of the blood falls to 42 per cent. (Himwich *et al.*, 1939) and that it is also decreased in electric fits and when fits are modified by curare or β-erythroidin (Himwich and Fazekas, 1942). Reduction also takes place when cardiazol, insulin or potassium cyanide are given without fits (Himwich and Fazekas, 1942). Oxygen saturation may be reduced still further by nitrous oxide inhalation (Himwich and Fazekas, 1942) or by nitrogen inhalation (Lipetz, 1940). Lipetz (1940) postulates the same action with the use of insulin, induced fits or nitrogen inhalation, the main difference being that insulin takes hours, while fits or nitrogen take seconds. That this is not the whole story is evident, if only because insulin produces its best results on schizophrenics, even when they show affective shallowness and thought disorder, while convulsions act best on patients with severe emotional overactivity, whether they be depressives, manics or cases of schizophrenic reaction. Furthermore, nitrous oxide and nitrogen inhalation, which should theoretically be more effective than convulsions by virtue of the more severe oxygen deprivation, have not in practice proved to be so. Ebaugh and Shanahan (1939) found "slightly" encouraging results with nitrous oxide and Lipetz results with nitrogen inhalation in 13 cases were promising, but Fogel and Gray's results (1940) with nitrous oxide inhalation in 24 schizophrenics were not very convincing, and Green and Adriani (1940) found nitrogen effects "strikingly neutral." Too few cases have been treated by these means to be dogmatic, but published results certainly show no superiority of direct oxygen depletion methods over convulsions. Bennett (1939) supports the anoxaemic theory, advocating prolonging the anoxia by closing the nose and mouth for half to one minute after the end of the fit.

The weight of evidence and opinions heavily leans towards the viewpoint that the convulsions exert their effect by putting groups of cerebral neurones out of action, whether by anoxaemia or other means. The correlation between leucotomy and convulsion therapy strongly supports this view. Leucotomy, which certainly cuts out large groups of cells, is most effective in the same types of case most favourable to convulsion therapy, Golla (1943), in fact, regarding ECT as a temporary leucotomy. This knowledge, to be of any use, however, must be correlated with the mental improvement, and we are still faced by the question—how is the improvement effected? E., E. S-. and L. Ziskind

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(1942) correlate the memory disorder, which they point out is of the organic type, with the improvement; they look upon the amnesia as the loss of a normal function, the recovery as the loss of an abnormal function. It has been suggested that the temporary brain cell damage causes a break in tension which enables a more rational attitude to be adopted later (Shapiro and Freeman, 1939), and that the general depression of activity following the fits, when restored, becomes normal activity (Birkmeyer, quoted by Kennedy, 1940). Müller (1939) quotes the view, originated by Stief and supported by Küppers, that the main effect of the convulsions is to knock out, transiently or permanently, diseased nerve-cells which are less resistant than healthy cells, and Bowman (1939) believes that the convulsions, by destroying dominating pathological cells, enable dominating healthy cells to exert their influence. Himwich and Fazekas (1942) suggest, "It may be that depression of brain metabolism with eclipse of cortical functions facilitates behaviour changes by permitting an expression of the more primitive cerebral mechanisms mediated by the subcortex but ordinarily held in cortical control." They point out that this view affords an excellent example of the Jacksonian conception of evolution and dissolution of the central nervous system, temporary dissolution resulting from the treatments. Berrington (1939) has evolved a similar conception of depression of cerebral metabolism, produced by areas of cerebral anaemia.

Results.

Although individual workers may have greater faith in one or other of the methods of inducing fits, there is no serious evidence that the method of induction—cardiazol or other drug injection or electric shock, with or without modifications—makes any significant difference to the results.

It has been shown conclusively that the fit, or rather the bodily changes set up by the fit, is the radical therapeutic factor and that subconvulsive twitchings or unconsciousness without convulsions cannot take the place of the fit.

Results of convulsion treatment will therefore be taken as a whole under clinical headings.

Schizophrenia.

Convulsion treatment came into being as a rational measure against the specific mental disorder of schizophrenia. There is therefore more than a touch of irony that convulsions have been found quite empirically to be of the foremost importance in the treatment of affective states, while, after nine years, controversy still rages as to their value in schizophrenia.

Evaluation of results in schizophrenia is beset with difficulties. Statistical assessments are particularly fallacious, as they depend on several factors which may vary infinitely with the individual investigator. The two main variables are the diagnosis and the standard of remission. Schizophrenia has no clear-cut diagnostic frontier. There is a no-man's land of "acute schizophrenic reaction states," "confusional psychoses," "atypical schizophrenias," etc., which tend to run a self-limited course. These states are included under schizophrenia in varying degrees, which considerably alter the balance of results.

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The standards of recovery, remission, etc., give even greater opportunities for discrepancies. Many will support Bleuler in refusing to admit full recovery in schizophrenia, but if so high a standard of normality be maintained, a significant proportion of the general population would not pass muster. To avoid so absolute a label as recovery the term remission has become popular, but unfortunately the term, with its many qualifications, is referred to anything from full recovery to material improvement.

Enough has been said to dissipate any surprise that spontaneous remission-rates for schizophrenia vary from *nil* to 48 per cent. under different observers. Treatment figures are even less reliable owing to the additional variable of case-selection. Some workers exclude all but frank endogenous schizophrenias; many give the more hopeful cases every chance of spontaneous remission before considering convulsion treatment. At the other end of the scale are workers who do not think it worth while to treat cases of insidious onset showing the hall-marks of endogenous schizophrenia and confine convulsion therapy to acute schizophrenic reaction states. The statistical differences in results from this factor alone are obvious.

Other variable factors influencing treatment figures are (1) the subjective bias of the investigator, (2) the influence of adjuvant treatment—psychotherapy, intensive occupational therapy, etc.—(3) the adequacy of the course of treatment.

Criteria of Remission.

It is generally agreed that recovery and complete or full remission are synonymous terms and should imply freedom from all symptoms, good insight and an ability to take up one's former employment or mode of occupation and place in society. Other grades of remission, great improvement, etc., have too many shades of meaning to be of much statistical value. It would be helpful if the term remission were confined to patients who at least had lost all symptoms of their incapacitating illness and were able to live a relatively independent existence outside hospital.

Treatment Results.

The relation between prognosis and length of illness is so constant that tabular results without classification into illness durations are virtually useless. Meduna's original figures were 91 per cent. remissions for schizophrenic illnesses of under one year's duration, 50 per cent. between one and two years, and 12 per cent. over two years. Although more recent figures are generally lower the ratio remains undisputed. Meduna and Friedman (1939) collected the results of 2,937 cardiazol-treated schizophrenic psychoses from 17 European and 37 American centres. Of the 1,472 European cases 50 per cent. (290 out of 584) of the cases below 18 months' duration were said to have attained full remissions as against 13 per cent. (101 out of 751) of those over 18 months. Of the 1,465 American cases, 49 per cent. (202 out of 411) of those under one year's duration were classed as full remissions as against 8·4 per cent. of those who had been ill for more than one year.

Reitmann (1939), from a collection of 840 schizophrenics of under 18 months'

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duration treated by cardiazol fits in various parts of the world, compiled the following table:

	Cases.	Full remissions.
Austria	64	32 (50%)
England	31	13 (41%)
Germany	129	51 (39%)
Hungary	178	94 (53%)
Italy	53	42 (79%)
Switzerland	51	22 (43%)
U.S.A.	334	183 (54%)
Total	840	437 (52%)

Many recent statistics have not specified illness durations, so that there are surprisingly few suitable figures to draw upon in proportion to the mass of treatments given and papers published. A summary of results from five sources (Nyberg, 1938; Meier, 1938; Read *et al.*, 1939; Delgood, 1939; Cummins, 1940) dealing with 142 cases of under 18 months' duration shows 44 (31 per cent.) full remissions, 32 (22·5 per cent.) social or good remissions and great improvements, 37 (26 per cent.) improvements and 29 (20·5 per cent.) no improvements. Martinengo (1939) assessed his complete remission-rate for schizophrenics under 18 months' duration as high as 75 per cent. and contrasted it with a rate of only 5 per cent. in cases over 1½ years' duration.

As regards cases under six months' duration a summary from seven sources (Meier, 1938; Nyberg, 1938; Hahnemann, 1939; Read *et al.*, 1939; Cummins, 1940; Reznikoff, 1940; Zeifert, 1941) gives these figures: Full remissions, 76 (43·4 per cent.); social, etc., remissions, 46 (26·3 per cent.); improved, 38 (21·7 per cent.); not improved, 15 (8·6 per cent.); total, 175. Zerbini (quoted by Müller, 1939) obtained 65·4 per cent. remissions in 182 cases, Kalinowsky and Worthing (1943) 67·4 per cent. remissions in 46 cases, and Beckenstein (1939) found that 69·6 per cent. of 23 cases became well enough to be paroled from hospital and 91·3 per cent. showed definite improvement.

Taking one year as the assessment factor, remission-rates show but a medium fall, Zerbini giving 62 per cent., Cohen (1939*a*) 59 per cent., and Kalinowsky and Worthing (1943) 56·8 per cent.; Corwin and Voth (1941) contrast their remission-rates of 60 per cent. for cases under one year's duration with 20 per cent. for those above that period.

These results differ strikingly from those of Pollock (1939) and Kwalwasser (1940). Pollock, surveying the results of convulsion treatment in the New York State Hospitals, gives percentage figures for the various durations; these work out as approximately 9·6 per cent. recovered and 31·1 per cent. much improved in cases under six months' duration, and 7·1 per cent. recovered and 30·3 per cent. much improved in cases under one year's duration. Kwalwasser, also supplying only percentage figures, found no recoveries at all; 18·5 per cent. of 16 cases under six months were much improved, as were 33·3 per cent. of 30 cases of six to twelve months' duration and 13·8 per cent. of 80 cases whose illness had lasted one to two years; above two years the ratio

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fell to approximately 2½ per cent. The fact that no single recovery was reported among Kwalwasser's 425 cases and that in Pollock's survey one hospital reported no recoveries in 275 cases and another 5 in 329 cases, suggests that some cautiousness in assessing recovery more than any other factor is responsible for the very low figures. This view is supported by Kwalwasser finding no recoveries or great improvements in five " depressed manic-depressives " treated by convulsions. Surveying all the various opinions I think it is justifiable to assume that between 55 and 60 per cent. of cases of schizophrenia, including schizophrenic reaction states, treated by convulsions in the first year of their illness may be expected to remit sufficiently to take their former place in society.

As regards more chronic cases *complete* recovery is rare, for as Bowman (1939) has pointed out, " it can hardly be expected that one is going to make an ideal personality out of a schizophrenic patient who has been treated," just as " . . . a patient who has had pneumonia may never completely recover so that his lungs are as good as they were before the attack." In this connection the preference of Kalinowsky and Worthing (1943) for the common term " remission," denoting absence of any active psychotic symptoms and ability to take up a former life in the community (as against a division into " recovered " and " greatly improved "), provides a more reasonable working basis for assessing results.

The value of convulsion treatment in schizophrenia dwindles rapidly with length of illness and in the later stages there is probably little or no greater prospect of lasting remission than may occur spontaneously. Social remissions of a degree allowing any real independence are probably from 5 to 10 per cent. after two years' illness, and almost certainly less than 5 per cent. after three years'. Improvement in conduct, however, is often seen. Cohen (1938) treated 40 schizophrenics showing chronic excitement and overactivity with marked success. Overactivity, aggressiveness, destructiveness and incontinence were much improved, the necessity for sedatives dropped to vanishing point and about half became capable of productive work. Good results are claimed by many others (Cook, 1938*a*; Bellenger, 1939; Sogliani, 1939*b*; Phillips and Duncan, 1940; Hemphill and Walter, 1941; Zeifert, 1941). Unfortunately these symptomatic improvements are mainly transient. A substantial number of more permanent conduct improvements may be expected, however, if advantage is taken of the more accessible phase produced by an adequate course of convulsions, which may include weekly maintenance doses over a period of several months, to implement intensive rehabilitation in the form of occupation' therapy, physical drill and games, as well as psychotherapeutic encouragement and explanation.

Stuporose patients usually improve rapidly under treatment, and as a rule become more accessible, take their food satisfactorily and cease to be incontinent after a few fits, but tend to relapse when treatment is stopped. A phase of catatonic excitement may be precipitated in chronic stupor states. Kalinowsky and Worthing (1943) observe that deeply regressed, quiet, deteriorated schizophrenics may become chronically disturbed and should not be treated.

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Prognostic Factors.

Next to duration by far the most important single prognostic factor in schizophrenia is the type of onset. This is well recognized as regards spontaneous remissions (Langfeldt, 1937), but has not been sufficiently stressed with reference to convulsion treatment. Rapid onset, particularly on a background of normal personality, offers the most favourable of prognoses whatever the clinical picture (Cook, 1938*b*); insidious onset emerging imperceptibly from adolescent schizoid personality is practically hopeless (Cook, 1938*a*). Kalinowsky and Worthing (1943) found that of 74 cases with remission the onset was described as acute in 58 and insidious in 16; in 57 unimproved patients the onset was apparently acute in only 19 and insidious in 38. They conclude that " insidious onset is of ominous significance."

The significance of regression (Beckenstein, 1939), dissociation (Cook, 1938*b*), and affect loss (Rosal, 1939) in prognosis is important. Cases with lively affect, particularly with hallucinations producing agitation, apprehension and horror, may be confidently expected to do well; those with flattened affect and pronounced apathy, possibly in the face of hallucinations and delusions of a profoundly distressing character, are usually therapeutic failures.

Comparative prognosis of the various sub-types of schizophrenia is vitiated by the fluidity of the classification as well as by the factors of length of illness, type of onset and emotional content. It is generally agreed that young hebephrenics are the least favourable sub-type (Pollock, 1939; Notkin *et al.*, 1940; Kalinowsky and Worthing, 1943), despite Meduna's original contrary opinion. Kalinowsky and Worthing (1943) consider paranoid schizophrenia with delusions and hallucinations to have the best outcome; Beckenstein (1939) gives " paroled " figures of 30·8 per cent. for paranoids, 23·6 per cent. for catatonics and 14·3 per cent. for hebephrenics. Here again a change of view is noticeable, mainly due to the realization that the striking early improvements in catatonic stupors tend to be superficial and transient. Catatonics of short duration react dramatically to a few fits, but improvement is maintained longer in paranoid patients (Reznikoff, 1940). Kolb and Vogel's survey (1942) reveals the general view of American hospitals that catatonic states are the most suitable for convulsion treatment.

Remitting cases.—Patients liable to recurrent schizophrenic attacks bear a good treatment prognosis (Reznikoff, 1940; Kalinowsky and Worthing, 1943), which tends to be more nearly relative to the length of the immediate attack than to that of the total psychotic history.

Children.—Cottington (1941) records improvement in eight out of nine schizophrenic children aged 6 to 14 years, treated with cardiazol fits modified by β-erythroidin hydrochloride. The danger of producing epilepsy is likely to be very much greater in childhood, and should be seriously considered before convulsion treatment is prescribed.

Evaluation.

Spontaneous remissions.—The average spontaneous remission-rate for unselected cases of all types and durations of schizophrenia has been estimated by Müller as probably between 15 and 20 per cent. Ebaugh and

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Shanahan (1939) give a comparable figure of 10–30 per cent. While bearing in mind how many factors are bound to vitiate any conclusions in this field, it is clear that the majority of published findings reveal a much higher remission-rate in schizophrenics treated by convulsions in the first 18 months of their illness. Any complacency, however, as to the results of convulsion treatment in schizophrenia must be shaken by the detailed analyses of results at the New York State Hospitals by Malzberg (1938), Pollock (1939), and Ross and Malzberg (1939). These analyses showed 11·1 per cent. recoveries and 26·5 per cent. great improvements with insulin therapy, 3·5 per cent. recoveries and 11·2 per cent. great improvements in cases not treated by shock methods, and only 1·6 per cent. recoveries and 9·9 per cent. great improvements with metrazol fits. While these papers have exerted a profound influence and engendered a much more critical attitude among investigators, it is only fair to say that other workers do not confirm these findings. Androp and Green (1941), comparing 82 schizophrenics of durations averaging 4½ years with 212 unselected untreated schizophrenics, noted that 18 per cent. of the treated cases were able to leave hospital with " social improvement " as against only 5 per cent. of the untreated group. Notkin *et al.* (1940), in a somewhat similar investigation, found 18 per cent. improvements in their treated, and 8·4 per cent. in their untreated group. Such discrepancies only serve to emphasize the difficulties of evaluation.

Insulin and convulsion treatments.—It must be emphasized that there should be no rivalry between insulin and convulsion therapy. The two treatments are complementary, and do not influence the various schizophrenic types equally. Insulin is said to be more successful in clearing up thought disorder and affect loss, and therefore tends to produce better results in true schizophrenia. Convulsions are the method of choice with florid symptomatology and retained affect. The type of case likely to do well with one or the other method can be fairly well estimated and the more favourable method given first. While more cases are likely to benefit from insulin it is advisable to give convulsion therapy prior trial, whenever there is a reasonable prospect of benefit, owing to its shorter duration and greater simplicity, safety and economy. In all probability insulin is the more consistently beneficial over all types of schizophrenia (Ross and Malzberg, 1939; Bowman *et al.*, 1939; Müller, 1939; Weinberg and Goldstein, 1942), but Kalinowsky and Worthing (1943) stress the similarity of results when schizophrenia is adequately treated by either method.

Combined insulin-metrazol treatment has been advocated (Georgi and Strauss, 1938; Russell, 1938; Tillim, 1940; Notkin *et al.*, 1943), but its most cogent *raison d'être*, to eliminate the fear associated with the induction of cardiazol fits (Russell, 1938; Sands, 1939; Notkin *et al.*, 1943), has been removed by ECT. Müller (1939), collecting results of insulin, cardiazol and combined treatment from German University Clinics, reported 40·3 per cent. cases symptom-free after the combined method, as against 37·7 per cent. with insulin alone and 18·9 per cent. with convulsions alone. Statistical results of the combined method can have no validity, however, unless compared with a similar series of patients who have had the opportunity to receive both treatments, if necessary. Although the main reasons for simultaneous combined

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insulin-convulsion treatment are no longer valid, both treatments should be available for every case. In many schizophrenic states there is an obvious emotional component, e.g. agitation, apprehension, etc., which may clear up under convulsions, leaving the underlying thought disorder wholly or partially untouched. A course of insulin, possibly shorter and less deep than when given as the sole treatment, may then suffice to remove the remaining symptoms.

Apart from numerical considerations certain other aspects must influence any evaluation of treatment. Doubtless many schizophrenics discharged after convulsion treatment would eventually have recovered spontaneously, but it is generally agreed that their period of hospitalization is markedly shortened by treatment (Meduna and Friedman, 1939; Cummins, 1940; Reznikoff, 1940; Androp and Green, 1941). Cheney *et al.* (1941*a*) adopt an admirably conservative viewpoint in stating " . . . metrazol treatment brings about a change which facilitates other forms of treatment and accelerates recovery, so that hospitalization is shortened, sometimes in a strikingly dramatic manner." The quality and length of treatment remissions as compared with spontaneous remissions is not so easily settled. Meduna and Friedman (1939) and Cummins (1940) consider treatment remissions superior both in quantity and quality, and, although Notkin *et al.* (1943) hold the contrary view, personal experience convincingly supports the former opinion.

Lastly, the attitude of the patients towards treatment must be considered. Weinberg *et al.* (1940) studied the reactions of 24 cases of spontaneous recovery, and 24 similar cases recovered after insulin or convulsion treatment; of these, 12 in each group were schizophrenics. They found that the former tended to have a real dread of the disease, and to worry that a relapse would place them in hospital for life. The treated group did not brood over the psychotic episode and felt that, if they became ill again, there was a remedy. In addition they felt that the hospital had done everything possible to get them well, whereas the spontaneously recovered group were apt to credit time and not medical aid for their discharge, and in some cases to bear slight resentment against the institution.

Affective Psychoses.

It may be said at once that no doubt exists as to the efficacy of convulsion treatment in affective psychoses; in fact it has claims to be little less than a specific. Early results were published by Verstraeten (1937), followed by Serko (1938) in Germany, Low *et al.* (1938) in U.S.A., and Cook and Ogden (1938) in England. Later conclusions have confirmed the early favourable reports.

As regards psychotic depressions as a whole, Müller (1939) (collected results) showed 58 per cent. recovered and 13 per cent. unimproved in 148 cases, Bennett (1941) 53 per cent. recovered and another 44 per cent. socially remitted and only 4 per cent. not improved in 146 cases, Furst and Stouffer (1942) 75 per cent. discharged with or without insight and 11 per cent. unimproved out of 65 cases, Osgood (1942) 83·5 per cent. discharged recovered or greatly improved and 5·5 per cent. unimproved out of 91 cases, and Fitzgerald (1943) 78 per cent. recovered and 4·7 per cent. not improved out of 150 cases. Perhaps

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the most noteworthy feature is the small number of unimproved cases, a collection of 690 cases yielding only 50 (just over 7 per cent.). Among a wealth of references only three are unfavourable; Kwalwasser (1940) found no remissions in 5 depressive cases, Kepner (1941) had scant success in treating 24 depressives in Hawaii, and Read *et al.* (1939) reported discouraging results in 8 involutional melancholics.

There is widespread agreement that duration of illness plays a far less important prognostic role in affective psychoses than in schizophrenia (Low *et al.*, 1938; Mader, 1938; Cottington, 1939; Cummins, 1940; Corwin and Voth, 1941). Osgood (1942) obtained 57 recoveries or great improvements out of 63 depressives under one year's duration, and 9 out of 13 over two years. Fitzgerald (1943) obtained 76 recoveries out of 89 depressives under one year, 13 out of 17 between two and three years, and 9 out of 20 over three years. He concludes that duration of illness does not influence results provided it is under three years. Sogliani (1939*a*) obtained 81 per cent. remissions in mainly chronic cases not improved by other means, and Corwin and Voth (1941) 50 per cent. remissions in cases ill over one year. This is of the utmost importance when one considers the large numbers of chronic melancholics to be seen in every mental hospital.

The presence of anxiety (Mader, 1938; R. H. and G. A. Young, 1939; Osgood, 1942), of compulsion features (Mader, 1938), or of schizophrenic features (R. H. and G. A. Young, 1939) in a depressive setting is said to be unfavourable.

Involutional depressive states, where tabulated separately, show results similar to "manic-depressive" or undifferentiated depressions, a collection from six sources showing 52 per cent. recovered, 20 per cent. incomplete remissions, and 10·5 per cent. unimproved. The commonly accepted spontaneous remission-rate for involutional depressions is 20–40 per cent. The rather higher "unimproved" rate in involutional states, compared with depressions as a whole, is not surprising considering the greater tendency to underlying vascular brain lesions in the higher age-groups. Osgood (1942), analysing five disappointing cases, suggests that all therapeutic failures may possibly be due to the presence of irreversible organic brain lesions. Good results are obtained in cases of three and four years' duration (Sogliani, 1939*b*).

Convulsion therapy has without doubt proved a boon in involutional melancholic states. Smith *et al.* (1942), who consider it should be reserved for such states, observe that the recovery of long-standing agitated depressions makes a profound impression, while others (Mader, 1938; Bennett, 1939) obtained their best results in climacteric and presenile depressions. Palmer *et al.* (1941), treating 27 involutional melancholics with cardiazol fits, 12 by prolonged narcosis, and 36 with endocrine extracts, found definitely superior results from convulsions.

Separate figures for manic phases are not often given and I can collect only 56 cases suitable for tabulating. These show 46 per cent. recoveries, 34 per cent. social or other remissions, and 12·5 per cent. unimproved. General opinion is definitely favourable, and suggests that the treatment prognosis in mania is only slightly less good than in depression. Cronick *et al.* (1940) believe

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that in the very early stages of a manic attack there is a refractory period to fits; after this, fits evoke a quick response, but relapse follows cessation of treatment. Later, after the period of potential mania has spent itself, the attack may be rapidly ended with a few fits; depression on the other hand tends to show a gradual lysis.

Adequate courses and tendency to relapse.—In assessing the value of convulsive therapy in affective states the question of relapse is important. With too few fits there is the same likelihood of relapse within a few weeks as in schizophrenia, but this usually clears up rapidly with a few further convulsions. E., E. S-., and L. Ziskind (1942), in stressing the importance of giving a sufficient number of convulsions, state that out of 21 patients receiving adequate therapy all had persisting full remissions, while of 17 receiving inadequate therapy 11 relapsed. Zeifert (1941) found no relapses in 18 patients who recovered sufficiently to leave hospital, but Fitzgerald (1943) reported 12 relapses in 135 discharged depressives. In neither case did the time factor appear to be sufficient to class these relapses as fresh attacks. Temporary hypomanic swings after treatment of depressions are not uncommon (Osgood, 1942).

Hospitalization is undoubtedly reduced (Smith *et al.*, 1942; E., E. S-. and L. Ziskind, 1942). Shelton (1942) observed the startling difference of 6 weeks for convulsion treated as against 63 weeks for spontaneously remitting affective states. E., E. S-. and L. Ziskind (1942) found an average reduction of $4\frac{1}{2}$ months. The same authors, in an interesting study of 38 cardiazol treated and 47 untreated affective states, obtained 82 per cent. full remissions in the treated group and 38 per cent. full remissions in the untreated group. Only 5 per cent. of the treated group were unimproved, as against 17 per cent. of the untreated group. These figures are all the more convincing, because 22 of the 47 untreated patients did not have treatment solely because their symptoms were too mild to warrant it, the remaining 25 either refusing treatment or being physically unfit. Among the treated group one committed suicide during a relapse after remission; of the untreated cases three committed suicide, and two died of exhaustion.

Psychoneuroses.

Published results of convulsion treatment of neuroses are scanty, and for the most part confined to a few cases. Good (1941), treating 40 war psychoneurotics who did not, or were judged unlikely to respond to ordinary psychotherapy, was not optimistic as to their ultimate prognosis, although 11 were able to return to military duty of some kind, and all but one improved in varying measure. Cheney *et al.* (1941*b*) obtained four recoveries and three great improvements in eight psychoneurotics, Zeifert (1941) two recoveries in three cases, and Low *et al.* (1938) three recoveries in three cases. Furst and Stouffer (1941), treating five cases of anxiety state, obtained four remissions with insight and one improvement. Shapiro and Freeman (1939) also reported good results. Pacella and Barrera (1943), however, found their results rather discouraging. Despite some successes, consideration of the fundamental make-up of psychoneurotic states renders it highly improbable that the underlying psychoneurotic personality will be influenced or that

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remissions will be lasting. The views, already mentioned, that anxiety or compulsion features in a depressive setting are unfavourable, indicate the general trend of opinion. It is possible that much of the success reported in treating psychoneurotics with convulsions consists in clearing up essentially depressive symptoms, which may often simulate neurotic anxiety.

Some acute hysterical manifestations may clear up with a few convulsions (Ingalls, 1939), just as they may react to any form of severe shock, but permanent cure is not as a rule to be expected.

Other Conditions.

Few mental disturbances have not been subjected to convulsion treatment. Kenyon *et al.* (1941) reported encouraging results of convulsion therapy on the psychotic symptoms of GPI, but it is noteworthy that the cases were mainly of the florid, emotional type and that improvement was purely symptomatic.

Avery and Campbell (1941) treated ten morphia addicts with daily cardiazol fits. Rapid reduction of morphine without withdrawal symptoms was made possible, but cure is not claimed.

To Owensby (1940) falls the distinction of making the most dramatic of reports. He claims to have treated one female and five male cases of confirmed and long-standing homosexuality with such success that after 6 to 15 fits all six patients lost their homosexual urges and acquired lasting heterosexual desires.

CONCLUSIONS.

Whatever the ultimate fate of convulsion therapy may be, there is little doubt of its increasing popularity. In this connection Kolb and Vogel's analysis (1942) of replies to a questionnaire sent to 356 hospitals in U.S.A. and Canada is of great interest. Replies were received from 305 hospitals, covering a total of 23,651 patients who had been treated with insulin in the years 1935–41 inclusive, and 44,608 patients who had been treated by metrazol or electric convulsions in the years 1936–41 inclusive. Graphs show that the number of hospitals using insulin reached its peak (54 per cent.) in 1938. In 1941 the figure had dropped to 47 per cent. Metrazol reached its peak of 65 per cent. in 1939 and is now falling with the rapid rise of ECT, which in 1940 was used in only 10 per cent. hospitals as against 42 per cent. in 1941. The use of insulin appeared to be declining mainly because of the cost and difficulties of administration as compared with convulsion treatment. Of 111 hospitals which had used all three methods, nearly 60 per cent. preferred ECT, 8 per cent. metrazol, 13 per cent. insulin, 7 per cent. some combination, and 13 per cent. were undecided or did not state. Of the hospitals employing insulin 96 per cent. used it for schizophrenia, 25 per cent. for manic-depressive states and 14 per cent. for involutional melancholia; of those employing metrazol 81 per cent. used it for schizophrenia, 73 per cent. for manic-depressive states, and 67 per cent. for involutional melancholia; of those employing ECT 79 per cent. used it for schizophrenia, 86 per cent. for manic-depressive states, and 73 per cent. for involutional melancholia. General opinion was overwhelmingly in favour

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of convulsion therapy in affective states, but doubtful as regards schizophrenia, for which insulin was regarded as more effective.

To sum up it may be said that in schizophrenia the position of convulsion treatment remains controversial. It appears to have a definite curative value in recent cases, with clear-cut onset, particularly when affect remains lively. In longer standing cases its benefits are mainly symptomatic. States of stupor and refusal of food can nearly always be relieved and faulty habits often corrected, albeit transiently. Maintenance courses of weekly treatments are sometimes helpful. Relapses are to be expected if treatment is stopped before full remission has been achieved.

In affective states the value of convulsion therapy is not open to doubt. Even in those cases which would eventually recover spontaneously convulsions cut short the acute symptoms, and with them the dangers of self-injury and exhaustion, the nursing difficulties and the period of hospitalization.

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