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CHAPTER 8

ECT AND PERMANENT BRAIN DAMAGE

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Electroconvulsive therapy (ECT) is a very controversial treatment. It is a topic for which it is difficult to obtain an objective perspective because emotional undercurrents tend to run strong. It may, in this respect, be comparable to other emotionally laden issues such as ethnic differences in IQ and the bad effects of marijuana. Friedberg (1977), an outspoken critic of ECT, attributed the rise of ECT in the 1930s to the authoritarian political era in Europe in which 275,000 "inmates" in German psychiatric hospitals were starved, beaten, drugged, and gassed to death. On the other hand, Shukla (1981) stated, "Despite abhorrence in some quarters, it is still being practiced as one of the cheapest and safest, and yet one of the most effective, therapeutic techniques in the whole of medical science" (p. 569).

Hoffmann (1986) provided a scholarly discussion of the philosophical differences between those who favor and those who are opposed to ECT. He said that the former have a paternalistic philosophy and those who oppose it have libertarian and Kantian assumptions. He argued, "Paternalism does not pay much attention to patient education or self-esteem and libertarian ethics do not consider patient pain, fear, or dependency." He said that traditionally medicine has operated from a paternalistic point of view and that the attack on ECT can be viewed as arising from the valuing of freedom and autonomy in our society, plus the fact that politically educated persons have little tolerance for obligatory government rule. However, it is here noted by the present author that a study indicated that the psychiatrists and other mental health professionals who were more favorably disposed toward ECT were more experienced and knew more correct facts about ECT (Janicak, Mark, Trimakas, & Gibbons, 1985).

The use of ECT in the United States is decreasing. In fact, there was a 46% decrease from 1975 to 1980. However, even in 1980 there were 33,384 psychiatric patients given ECT (Thompson & Blain, 1987). In California, legislation in 1975 severely restricted the use of ECT. Nevertheless, from 1977 to 1983, 18,627 patients received a total of 99,425 ECT treatments in California, with little year-to-year variation (Kramer, 1985). ECT is far from becoming an obsolete treatment modality. And, because controlled research has demonstrated its efficacy, and

because it is especially valued in the recalcitrant cases of depression that do not respond to antidepressant drugs, it is not going to become an obsolete treatment unless and until more effective antidepressant drugs are developed. Janicak, Davis, Gibbons, Ericksen, Chang, and Gallagher (1985) published a meta-analysis that showed ECT to be clearly superior to the tricyclic antidepressants, the monoamine oxidase (MAO) inhibitors, simulated ECT, and placebo for severe depression.

This review covers eight areas relevant to the issue of permanent brain damage caused by ECT. These are (a) subjective report long after ECT, (b) human brain autopsy reports, (c) animal brain studies, (d) the brains of epileptics, (e) spontaneous seizures, (f) psychological test findings in patients with history of many ECT, (g) CT scan findings, and (h) magnetic resonance imaging (MRI) findings.

It is important that the reader be aware of the importance of distinguishing between the modern era of ECT administration with hyperoxygenation, muscle relaxation, and general anaesthesia, and ECT administration before the 1960s, which was less safe for the brain. A number of researchers and authorities have emphasized this distinction (Janicak, Mark, Trimakas, & Gibbons, 1985; Weiner, 1979; d'Elia & Raotma, 1975; Kendell & Pratt, 1983).

It is also important for the reader to bear in mind that unmodified ECT is often administered in third world countries (Weiner, 1984). The brains of poor people in poor countries also deserve protection. Shukla (1981) stated that in India, because of the shortage of anesthesiologists, most psychiatric centers, even in teaching centers, often have to use unmodified ECT that is followed by severe confusion. In India, ECT is used much more often than in the United States and is the mainstay of treatment for schizophrenia.

SUBJECTIVE REPORT

It is common knowledge that most patients complain of memory impairment during and after their course of ECT. There have been at least four studies that have investigated subjective reports of memory deficit long after it is expected that this impairment should have dissipated.

Freeman, Weeks, and Kendell (1980) placed a notice in a local newspaper in the United Kingdom asking for participation of subjects who had ECT at any time in their lives. In addition to the 13 subjects thusly recruited, there were 12 subjects who had been identified as complainers of impairment and referred by local psychiatrists. There were two main sorts of memory complaints. One was forgetfulness of such things as faces, names, phone numbers, and messages. The other was that of holes or gaps in past memories. Furthermore, these subjects' scores on neuropsychological tests were inferior to those of control persons. Needless to say, the generalizability of these findings is very limited because of

the subject selection process. Nevertheless, these findings do mesh with other studies concerning the memory complaints of patients who had a past history of ECT.

One hundred and sixty-six patients who had ECT from 1 to 7 years before were interviewed. Although a clear majority of the patients viewed the treatment as beneficial, 30% stated thaty believed the ECT produced lasting memory impairment (Freeman & Kendell, 1980).

Squire and Slater (1983) followed up 31 patients 3 years after ECT. Eighteen (58%) of the respondents said they did not think their memory was as good as for most people their age. Seventeen of these 18 persons attributed their memory difficulty to ECT.

In summary, there is a good accumulation of evidence that many patients complain of memory impairment attributed to their ECT years before. The authors of these studies pointed out that these reports do not provide conclusive evidence that such impairment actually exists. Nevertheless, these reports do legislate against a completely confident bill of health for ECT.

ANIMAL BRAIN STUDIES

Perhaps the most reasonable omnibus generalization is that many animal studies have been carried out, and that some authors have reported permanent damage and some authors have not reported permanent brain damage. In the 15-study review of Hartelius (1952), 13 of the 15 reported pathological findings that were vascular, glial, or neurocytological—or (as was generally the case) in two or three of these domains. However, as Hartelius pointed out, inferences of these studies tended to be conflicting because of different methods used and because of deficient controls. The research that Hartelius himself carried out was unquestionably the outstanding study in the area with respect to methodological sophistication and rigor. Hartelius employed 47 cats, 31 receiving ECT and 16 being control animals. To prevent artifacts associated with the sacrificing of the animals, the cerebrums were removed under anesthesia while the animals were still alive. Brain examinations were conducted blindly with respect to ECT versus control subject. On a number of different vascular, glial, and neuronal variables, the ECT animals were significantly differentiated from the controls. The animals that had 11-16 ECTs had significantly greater pathology than the animals that had received four ECTs. Most of the significant differences were with respect to reversible-type changes. However, some of the significant differences pertained to clearly irreversible changes such as shadow cells and neuronophagia.

The preponderance of human and animal autopsy studies were carried out prior to the modern era of ECT administration that included anesthesia, muscle relaxants, and hyperoxygenation. In fact, animals that were paralyzed and artificially ventilated on oxygen had brain damage of somewhat lesser magnitude

than, although similarly patterned as, animals not convulsed without special measures (Meldrum & Brierley, 1973; Meldrum, Vigourocex, & Brierly, 1973).

Needless to say, the generalization from these studies to humans is most difficult because of the great variation in stimulus parameters and other properties of the ECT, the different types of animals, and varying sophistication of design. Nevertheless, there does seem to be one generalization that applies to both animals and humans. It is possible to cause definite permanent brain damage through ECT, and it is possible to administer ECT with minimal or no damage. It is not a matter of whether ECT can produce permanent damage but a matter of in what circumstances it occurs.

HUMAN BRAIN AUTOPSY REPORTS

In the 1940s and 1950s, there were a large number of reports concerning the examination of brains of persons who had died following ECT. Madow (1956) reviewed 38 such cases. In 31 of the 38 cases, there was vascular pathology. However, much of this could have been of a potentially reversible nature. Such reversibility was much less with the 12 patients who had neuronal and/or glial pathology. In one case, the author (Riese, 1948), in addition to giving the neuronal and glial changes, reported numerous slits and rents similar to that seen after execution. Needless to say, patients who died following ECT are not representative of patients receiving ECT. They tended to be in inferior physical health. Madow concluded, on the basis of these 38 cases and five of his own, "If the individual being treated is well physically, most of the neuropathological changes are reversible. If, on the other hand, the patient has cardiac, vascular, or renal disease, the cerebral changes, chiefly vascular, may be permanent" (p. 347).

An interesting autopsy case report was presented by Lippmann et al. (1985). An 89-year-old woman with a long history of psychiatric illness died in 1982 after a documented history of 1250 bilateral treatments beginning in the 1920s. There was also some unsubstantiated evidence of her having received 800 additional ECTs. The authors stated that the moderate cerebral atrophy was consistent with her age and did not show old focal ischemic lesions or any evidence of brain injury resulting from the ECT. The author of the present chapter does believe that these clinical observations, even though based on an apparently nonblind determination, do argue in favor of the brain safety of ECT, especially since many of her treatments were administered prior to the modern era (1960 to present) of ECT administration. However, I raise the question of this woman's aging processes masking the ECT effects upon the brain many years earlier. I note that the authors stated that examination of the frontal lobes failed to reveal the sites of the cannula used in her prefrontal lobotomy in 1953.

CT SCANS

Calloway, Dolan, Jacoby, and Levy (1981) found no significant relationships between history of ECT and CT-scan-determined atrophy and ventricle size. However, a positive significant relationship between ECT and frontal lobe atrophy was found. Borderline significance was obtained with parietal atrophy. However, the authors appropriately raised the possibility that frontal lobe atrophy could have been present before ECT and in some way contributed to the patients receiving ECT.

Calloway, Dolan, and Jacoby (1988) found frontal lobe atrophy assessed by CT scans in 15 of 22 elderly depressed patients who had a history of ECT in contrast to four of 15 control patients without a history of ECT.

Weinberger, Torrey, Neophytides, and Wyatt (1979) found that those patients who had received ECT had significantly higher ventricle brain ratios than patients with no history of ECT.

One study found no relationship between CT scan assessed ventricular enlargement and number of life history of ECT in 27 bipolar patients (Pearlson et al. 1984). However, ECT was a minor part of this study and the authors did not specify how many patients received ECT. The details of ECT administration were also not specified. However, since the patients were from 18 and 40 years of age and presumably living in the United States, a reasonable assumption is that they received modern era administration with oxygenation, sedation, and general anaesthesia.

Kendell and Pratt (1983) presented CT findings on 12 patients who had a history of from 14 and 398 and a median of 94 ECT which were predominantly to the nondominant hemisphere. In two cases, CT scans were performed before history of ECT. In five cases, scans were obtained early in the course of treatment after two to six treatments. In all 12 patients, examinations were made at the end of therapy, which had lasted from over 1–40 years. Neither blind assessment of CT scans nor ventricle measurement pointed to effects of ECT upon the brain. Any increase in atrophy over the years was described as minimal and either bilateral or equally ipsilateral and contralateral to the treated hemisphere. The authors concluded that the absence of CT changes cannot exclude damage but that it is encouraging that CT showed no evidence of this occurring with prolonged courses of ECT taking place over widely varying period of time.

Kolbeinson, Arnoldson, Petruson, and Skulason (1986) found that 22 patients with a history of ECT did not differ in CT scan findings from control patients without a history of ECT. Neither atrophy scores nor ventricle brain ratios differentiated the two groups.

One patient was given a CT scan the day before and 3 hours after multiple ECT that consisted of 10 ECT in a period of 45 minutes (Menken, Safer, Goldfarb, & Varga, 1979). The patient was very confused, disoriented with

respect to time and place, and amnestic for events before the day of ECT. Nevertheless, no CT changes were observed. The findings would appear to point to the safeness of the ECT. However, the present author is willing to entertain an alternative explanation. If the CT did not reflect the massive acute brain syndrome with gross disorientation, then it may not be capable of detecting minor changes in patients months or years after the ECT. Perhaps the CT scan is not the most optimal tool for ruling out brain changes resulting from ECT.

A reasonable generalization may be that CT scans have failed to provide a definitive perspective with respect to the matter of permanent brain damage.

MAGNETIC RESONANCE IMAGING

Coffey and colleagues (1988) reported on magnetic resonance imaging before and after ECT administered to nine depressed patients. Blind raters' assessments showed no significant differences between pre- and postECT in cortical atrophy and global comparison. There were also no significant changes in ventricle brain ratios. Furthermore, patients with preexisting brain disease showed no worsening. However, the authors did state: "Still these observations need to be confirmed in a larger number of subjects with techniques that will quantitate even subtle brain changes which might otherwise not be detected by qualitative clinical assessments. Further studies should also include patients with histories of previous ECT (to evaluate any potential cumulative effects) and should involve long-term follow-up studies including both subjective and objective measures of memory function" (p. 706).

A case report of a multiple sclerosis patient with magnetic resonance imaging before and after ECT is reassuring. There was no evidence of changes in white matter lesions visualized on spin-echo images (Coffee, Weiner, McCall, & Heinz, 1987).

In summary, the two studies using magnetic resonance imaging did not provide evidence of permanent brain damage resulting from ECT. However, more studies are needed.

PSYCHOLOGICAL TESTING WITH PAST HISTORY OF MANY ECTS

Goldman, Gomer, and Templer (1972) administered the Bender-Gestalt and the Benton Visual Retention Test to schizophrenics in a VA hospital. Twenty had a past history of from 50 to 219 ECTs, and 20 had no history of ECT. The ECT patients did significantly worse on both instruments. Furthermore, within the ECT groups there were significant inverse correlations between performance on these tests and number of ECTs received. However, the authors acknowledge that

ECT-caused brain damage could not be conclusively inferred because of the possibility that the ECT patients were more psychiatrically disturbed and for this reason received the treatment. (Schizophrenics tend to do poorly on tests of organicity.) In a subsequent study aimed at ruling out this possibility, Templer, Ruff, and Armstrong (1973) administered the Bender-Gestalt, the Benton, and the Wechsler Adult Intelligence Scale to 22 state-hospitalized schizophrenics who had a past history of from 40 to 263 ECTs and to 22 control schizophrenics. The ECT patients were significantly inferior on all three tests. However, the ECT patients were found to be more psychotic. Nevertheless, with degree of psychosis controlled for, the performance of the ECT patients was still significantly inferior on the Bender-Gestalt, although not significantly so on the other two tests.

Thus, the research using psychological tests with patients with history of many ECTs does suggest permanent impairment. However, one should bear in mind that retrospective studies do not permit the same confidence as do prospective studies. Also, the ECT in these studies was administered before the modern era of ECT.

BRAINS OF EPILEPTICS

It would seem that if an epileptic grand mal seizure produces permanent brain changes, then an electrically induced convulsion should also do so. In fact, inspecting the evidence with respect to epileptics may provide us with a conservative perspective in regard to ECT because the latter could produce damage from the externally applied electrical current as well as from the seizure. Experimental research with animals has shown that electric shocks (not to the head) produce more deleterious effects in the central nervous system than any other locality or system of the body. More pertinent are the studies of Small (1974) and of Laurell (1979) that found less memory impairment after inhalant-induced convulsions than ECT. Also, Levy, Serota, and Grinker (1942) reported less EEG abnormality and intellectual impairment with pharmacologically induced convulsions. Further argument provided by Friedberg (1977) is the case (Larsen & Vraa-Jensen, 1953) of a man who had been given four ECTs, but did not convulse. When he died 3 days later, a subarachnoid hemorrhage was found in the upper part of the left motor region "at the site where an electrode had been applied" (p. 18).

A number of postmortem reports on epileptics, as reviewed by Meldrum, Horton, and Brierley (1974) have indicated neuronal loss and gliosis, especially in the hippocampus and temporal lobe. However, as Meldrum et al. (1974) pointed out, on the basis of these postmortem reports, one does not know whether the damage was caused by the seizures or whether both were caused by a third factor intrinsic to the epilepsy. To clarify this issue, Meldrum et al. (1974) pharmacologically induced seizures in baboons and found cell changes that corresponded to those in human epileptics.

Gastaut and Gastaut (1976) demonstrated through brain scans that in seven of 20 cases status epilepticus produced brain atrophy. They reasoned, "Since the edema and the atrophy were unilateral and bilateral and related to the localization of the convulsions (unilateral or bilateral chronic seizures), the conclusion can be drawn that the atrophic process depends upon the epileptic process and not on the cause of the status" (p. 18).

A common finding in epileptics and ECT patients is noteworthy. Norman (1964) stated that it is not uncommon to find at autopsy both old and recent lesions in the brains of epileptics. Alpers and Hughes (1942) reported old and recent brain lesions associated with different series of ECT.

SPONTANEOUS SEIZURES

The reports of spontaneous seizures, which appeared in the pre-1960s ECT era, probably do not constitute one of the more definitive domains. However, this section is included to increase breadth of perspective.

It would appear that if seizures that were not previously evidenced appeared after ECT and persisted, permanent brain pathology must be inferred. There have been numerous cases of postECT spontaneous seizures reported in the literature and briefly reviewed by Blumenthal (1955), Pacella and Barrera (1945), and Karliner (1956). It appears that in the majority of cases the seizures do not persist indefinitely, although an exact perspective is difficult to obtain because of anticonvulsant medication employed and the limited follow-up information. Another difficulty is, in all cases, definitively tracing the etiology to the ECT, since spontaneous seizures develop in only a very small proportion of patients given this treatment. Nevertheless, the composite of relevant literature does indicate that, at least in some patients, no evidence of seizure potential existed before treatment and postECT seizures persist for years.

An article that is one of the most systematic and representative in terms of findings is that of Blumenthal (1955) who reported on 12 schizophrenic patients in one hospital who developed postECT convulsions. Six of the patients had previous EEGs with four of them being normal, one clearly abnormal, and one mildly abnormal. The patients averaged 72 ECTs and 12 spontaneous seizures. The time from last treatment to first spontaneous seizure ranged from 12 hours to 11 months, with an average of 2½ months. The total duration of spontaneous seizures in the study period ranged from 1 day to 3½ years, with an average of 1 year. Following the onset of seizures, eight of the 12 patients were found to have a clearly abnormal, and one a mildly abnormal EEG.

Masovich and Katzenelbogen (1948) reported that 20 of their 82 patients had convulsive pattern cerebral dysrhythmia 10 months post-ECT. None had such in their pretreatment EEG. Nine (15%) of the 60 patients who had three to 15 treatments, and 11 (50%) of the 22 patients who had from 16 to 42 treatments

($x^2 = 10.68$; $p < 0.01$, according to our calculations) had this 10-month post-treatment dysrhythmia.

SYNTHESIS

There seems to be little doubt that ECT always produces an acute brain syndrome and that such remits over time. There seems to be little doubt that ECT has, at least in the past, caused permanent brain damage in some patients and has the capacity to continue to do so. There also seems to be little doubt that modern era ECT has greater brain safety than that administered prior to the 1960s. It appears that the overwhelming majority of persons who currently receive ECT in the United States do not suffer from massive cognitive deficits caused by the ECT.

What percentage of persons who receive ECT suffer some permanent impairment? What are, if any, the long-term effects of ECT in the "typical" or "average" ECT patient? Can we tell most of our patients there is absolutely and positively no danger of any permanent brain changes? These are the sort of questions for which we cannot provide confident answers. The present author believes that the difficulties in answering such questions are similar to the questions regarding whether or not alcohol and alcoholism are associated with brain pathology. We do know that a small amount of alcohol produces changes in the brain in all alcoholics and in all normal drinkers. We also know that all or almost all of these effects rather quickly dissipate. We also know that some alcoholics have massive and permanent brain pathology, for example, as seen in Korsakoff's syndrome. We know that a large percentage of newly abstinent alcoholics suffer from neuropsychological deficits. We know that in many of these patients there is improvement in neuropsychological testing over time and in some patients even a retrenchment in cortical atrophy. However, when we attempt to supply the details to answers about the typical or average alcoholic, or even the specification of who are average or typical alcoholics, the situation becomes less clear. This is the difficult situation we face with ECT patients. Some authors argue that ECT is hazardous to the brain and others argue it is safe. I believe they are both right.

The crucial questions at this point in time are those centered around in whom and in what circumstances are the risks higher and lower. We are able to make some generalizations. There is research evidence that type of ECT administration does have an effect upon degree of confusion and amnesia. Higher levels of stimulus intensity, stimulus waveforms that are relatively inefficient in seizure-eliciting properties, and bilateral electrode placement are associated with greater confusion and amnesia (Sackeim, Decena, Prohovnik, Malitz, & Resor, 1983; Cronholm & Ottossom, 1963; Ottossom, 1960; Valentine & Dunne, 1969; Weiner, Rogers, Welch, Davison, Weir, Cahill, & Squire, 1983; Sackeim, Portney, Neeley, Steif, Decema, & Malitz, 1986; Squire & Slater, 1978).

A convergence of evidence indicates the importance of number of ECTs. We have previously referred to the significant inverse correlations between number of ECTs and scores on psychological tests. It is conceivable that this could be a function of the more disturbed patients both receiving more ECTs and doing worse on tests. However, it would be much more difficult to explain away the relationship between number of ECTs received and EEG convulsive pattern dysrhythmia (Mosovich & Katzenelbogen, 1948). No patients had dysrhythmia prior to ECT. Also difficult to explain away is that in Table 1 of Meldrum, Horton and Brierley (1974), the nine baboons who suffered brain damage from experimentally administrated convulsions tended to have recevied more convulsions than the five that did not incur damage. (According to our calculations, $U = 9$, $p < 0.05$.) And, as already stated, Hartelius found greater damage, both reversible and irreversible, in cats that were given 11 to 16 than in those given four ECTs.

Throughout this review the vast individual differences are striking. In the animal and human autopsy studies there is typically a range of findings from no lasting effect to considerable lasting damage with the latter being more of the exception. Most ECT patients do not have spontaneous seizures, but some do. The subjective reports of patients likewise differ from those of no lasting effect to appreciable, although usually not devastating, impairment. The fact that many patients and subjects suffer no demonstrable permanent effects has provided rationale for some authorities to commit the *nonsequitur* that ECT causes no permanent harm.

There is evidence to suggest that preECT physical condition accounts in part for the vast individual differences. Jacobs (1944) determined the cerebrospinal fluid protein and cell content before, during, and after a course of ECT with 21 patients. The one person who developed abnormal protein and cell elevations was a 57-year-old diabetic, hypertensive, arteriosclerotic woman. Jacobs recommended that CSF protein and cell counts be ascertained before and after ECT in patients with significant degree of arteriosclerotic or hypertensive disease. Alpers (1946) reported, "Autopsied cases suggest that brain damage is likely to occur in conditions with pre-existing brain damage, as in cerebral arteriosclerosis" (p. 369). Wilcox (1944) offered the clinical impression that, in older patients, ECT memory changes continue for a longer time than for younger patients. Hartelius (1952) found significantly more reversible and irreversible brain changes following ECT in older cats than younger cats. Mosovich and Katzenelbogen (1948) found that patients with pretreatment EEG abnormalities are more likely to show marked post-ECT cerebral dysrhythmia and to generally show EEGs more adversely affected by treatment.

RECOMMENDATIONS

It is recommended that more research be carried out on the safety and the hazards of ECT. Research on the unmodified ECT given in the developing countries of the world would seem to be especially important. The present author does not have the credentials to make recommendations concerning the brain safety precautions that should be followed. However, I here present the recommendations of Frankel et al. (1978) and those of Weiner (1984).

Weiner (1984) recommended that a careful analysis of risks and benefits be determined; that the possibility of persistent memory defects should be part of the informed consent procedure; that ordinarily unilateral nondominant electrode placement should be used; that EEG monitoring should be carried out; that instruction in sophisticated use of ECT should be in psychiatric residency programs and continuing education opportunities; that inspections of ECT equipment should be made; that the public should be better informed about ECT; and that more research be carried out.

Frankel et al. (1978) recommended that the patients receive a thorough pretreatment medical examination; that there be designated ECT and recovery room areas with availability of equipment, drugs, and personnel in the event of cardiopulmonary or other complications; that ECT be administered with anesthesia and muscle relaxant drugs and ventilatory assistance with a positive pressure bag and 100% oxygen, with EKG, blood pressure and pulse rate monitoring, and with appropriate electrode placement and electrical parameters; that ECT only be used in those conditions for which ECT efficacy has been established; that medical contraindications be considered; that the severity and unremitting nature of the patient's suffering and incapacitation and unresponsiveness to other treatments be taken into account; and that proper informed consent be obtained.

REFERENCES

Alpers, B. J. (1946). The brain changes associated with electrical shock treatment: A critical review. *Lancet, 66*, 363–369.

Blumenthal, I. J. (1955). Spontaneous seizures and related electroencephalographic findings following shock therapy. *Journal of Nervous and Mental Disease, 122*, 581–588.

Calloway, S. P., Dolan, R. J., Jacoby, R. J., & Levy, R. (1981). ECT and cerebral atrophy: A computer tomographic study. *Acta Psychiatrica Scandinavica, 63*, 442–445.

Coffey, C. E., Figiel, G. S., Djang, W. T., Sullivan, D. C., Herfkens, P. V., & Weiner, R. D. (1988). Effects of ECT or brain structure. *American Journal of Psychiatry, 145*, 701–706.

Cronholm, B., & Ottossom, J. O. (1963). Ultrabrief stimulus techniques in ECT. 1. Influence on retrograde amnesia. *Journal of Nervous and Mental Disease, 137*, 117–123.

d'Elia, G., & Frederiksen, S. O. (1980). ACTH4-10 and memory in ECT-treated and untreated patients. I. Effect on consolidation. *Acta Psychiatrica Scandinavica, 62*, 418–428.

d'Elia, G., & Roathma, H. (1975). Is unilateral ECT less effective than bilateral ECT? *British Journal of Psychiatry, 126*, 83–89.

Frankel, F. H., Bidder, T. G., Fink, M., Mandel, M. R., Small, I. F., Wayne, G. J., Squire, L. R., Dutton, E. N., & Gurel, L. (1978). *Electroconvulsive therapy. Report on the task force on*

electroconvulsive therapy of the American Psychiatric Association. Washington, DC: American Psychiatric Association.
Freeman, C. P. L., & Kendell, R. E. (1980). Patients' experiences of and attitudes to ECT. *British Journal of Psychiatry, 137*, 8–16.
Freeman, C. P. L., Weeks, D., & Kendell, R. E. (1980). ECT: Patients who complain. *British Journal of Psychiatry, 137*, 17–25.
Friedberg, J. (1977). ECT as a neurologic injury. *Psychiatric Opinion, 14*, 16–19.
Gastaut, H., & Gastaut, J. (1976). Computerized axial tomography in epilepsy. In J. K. Penry (Ed.), *The Eighth International Symposium*. New York: Raven Press.
Goldman, H., Gomer, F. E., & Templer, D. I. (1972). Long-term effects of electroconvulsive therapy upon memory and perceptual-motor performance. *Journal of Clinical Psychology, 28*, 32–34.
Hartelius, H. (1952). Cerebral changes following electrically induced convulsions: An experimental study on cats. *Acta Psychiatrica Et Neuroligica Scandinavica, 77*, 1–128.
Jacobs, J. S. L. (1944). The effect of electric shock therapy upon cerebrospinal fluid pressure, protein and cells. *American Journal of Psychiatry, 101*, 110–112.
Janicak, P. G., Davis, J. M., Gibbons, V. G., Ericksen, S., Chang, S., & Gallagher, P. (1985). Effects of ECT-A meta-analysis. *American Journal of Psychiatry, 142*, 297–302.
Janicak, P. G., Mark, J., Trimakas, K. A., & Gibbons, V. G. (1985). ECT: An assessment of mental health professionals' knowledge and attitudes. *Journal of Clinical Psychiatry, 46*, 262–266.
Karliner, W. (1956). Epileptic states following electroshock therapy. *Journal of Hillside Hospital, 5*, 258–263.
Kendell, B., & Pratt, R. T. C. (1983). *British Journal of Psychiatry, 143*, 99–100.
Kolbeinsson, H., Arnaldsson, O. S., Petursson, H., & Skulason, S. (1986). Computer tomographic scan in ECT patients. *Acta Psychiatrica Scandinavica, 73*, 28–32.
Kramer, B. A. (1985). Use of ECT in California, 1977–1983. *American Journal of Psychiatry, 142*, 1190–1192.
Larsen, E. F., & Vraa-Jensen, G. (1953). Ischaemic changes in the brain following electroshock therapy. *Acta Psychiatrica Et Neuroligica Scandinavica, 28*, 75–80.
Laurell, B. (1970). Flurothyl convulsive therapy. *Acta Psychiatrica Scandinavica, 213*, 5–79.
Levy, N. A., Serota, H. M., & Grinker, R. R. (1942). Disturbance in brain function following convulsive shock therapy. *Archives of Neurology and Psychiatry, 47*, 1000–1029.
Lippmann, S., Manshadi, M., Wehry, M., Byrol, R., Past, W., Keller, W., Schuster, J., Elam, S., Meyer, O., & O'Daniel, R. (1985). 1250 Electroconvulsant treatments without evidence of brain injury. *British Journal of Psychiatry, 147*, 203–204.
Madow, L. (1956). Brain changes in electroshock therapy. *American Journal of Psychiatry, 113*, 337–347.
Meldrum, B. S., & Brierley, J. B. (1973). Prolonged epileptic seizures in primates: Ischaemic cell change and its relation to ictal physiological event. *Archives of Neurology, 28*, 10–17.
Meldrum, B. S., Horton, R. W., & Brierley, J. B. (1974). Epileptic brain damage in adolescent baboons following seizures induced by allylglycine. *Brain, 97*, 407–418.
Meldrum, B. S., Vigouroux, R. A., & Brierley, J. B. (1973). Systemic factors and epileptic brain damage. *Archives of Neurology, 29*, 82–87.
Menken, M., Safer, J., Goldfarb, C., & Varga, E. (1979). Multiple ECT: Morphologic effects. *American Journal of Psychiatry, 136*, 453.
Mosovich, A., & Katzenelbogan, S. (1948). Electroshock therapy, clinical and elctroencephalographic studies. *Journal of Nervous and Mental Disease, 107*, 517–530.
Norman, R. M. (1964). The neuropathology of status epilepticus. *Medicine, Science and the Law, 4*, 46–51.

Ottosson, J. O. (1960). Experimental studies on the mode of action of electroconvulsive therapy. *Acta Psychiatrica et Neuroligica Scandinavica, 35*(suppl 145), 1–141.
Pacella, B. L., & Barrera, S. E. (1945). Spontaneous convulsions following convulsive shock therapy. *American Journal of Psychiatry, 102*, 783–788.
Pearlman, C. A., Sharpless, S. K., & Jarvik, M. E. (1961). Retrograde amnesia produced by anesthetic and convulsant agents. *Journal of Comparative and Physiological Psychology, 54*, 109–112.
Riese, W. (1948). Report of two new cases of sudden death after electric shock treatment with histopathological findings in the central nervous system. *Journal of Neuropathology and Experimental Neurology, 7*, 98.
Sackeim, H. A., Decina, P., Kanzler, M., & Ken, B. (1987). Effects of electrode placement on the efficacy of titrated, low dose ECT. *American Journal of Psychiatry, 144*, 1449–1455.
Sackeim, H. A., Decina, P., Prohovnik, I., Malitz, S., & Resor, S. R. (1983). Anticonvulsant and anti-depressant properties of ECT: A proposed mechanism of action. *Biological Psychiatry, 18*, 310–320.
Shukla, C. D. (1981). Electroconvulsive therapy in a rural teaching general hospital in India. *British Journal of Psychiatry, 139*, 569–571.
Siegel, M. A., Plesser, O. R., & Jacobs, N. R. (1987). *Domestica violena: no longer behind closed doors*. Plano, TX: Information Aids.
Small, J. G. (1974). EEG and neurophysiological studies of convulsive therapies. In M. Fink, S. Kety, J. McGaugh, & T. A. Williams (Eds.), *Psychobiology of Convulsive Therapy, Vol. 63* (pp. 79–86). Washington, DC:
Squire, L. R., & Slater, P. C. (1983). Electroconvulsive therapy and complaints of memory dysfunction: A prospective three-year follow-up study. *British Journal of Psychiatry, 142*, 1–8.
Templer, D. I., Ruff, C. F., & Armstrong, G. (1973). Cognitive functioning and degree of psychosis in schizophrenics given many electroconvulsive treatments. *British Journal of Psychiatry, 123*, 441–443.
Templer, D. I., & Veleber, D. M. (1982). Can ECT permanently harm the brain? *Clinical Neuropsychology, 4*, 62–66.
Thompson, J. W., & Blain, I. D. (1987). Use of ECT in the United States in 1975 and 1980. *American Journal of Psychiatry, 144*, 557–562.
Valentine, M., Keddie, K. M., & Dunne, D. (1968). A comparison of techniques in electroconvulsive therapy. *British Journal of Psychiatry, 114*, 989–996.
Weinberger, D. R., Torrey, E. F., Neophytides, A. N., & Wyatt, R. J. (1979). Lateral cerebral ventricular enlargement in chronic schizophrenia. *Archives of General Psychiatry, 36*, 735–739.
Weiner, R. D. (1979). The psychiatric use of electrically induced seizures. *American Journal of Psychiatry, 136*, 1507–1517.
Weiner, R. D., Rogers, H. J., Welch, C. A., Davidson, J. R. T., Miller, R. D., Weir, D., Cahill, J. F., & Squire, L. R. (1983). ECT stimulus parameters and electrode placement. In B. Lerer, R. D. Weiner, & R. H. Belmaker (Eds.), *ECT: Basic mechanisms*. London: John Libbey.
Weiner, R. D. (1984). Does electroconvulsive therapy cause brain damage? *The Behavioral and Brain Sciences, 7*, 1–54.
Wilcox, P. (1944). The electroshock convulsion syndrome. *American Journal of Psychiatry, 100*, 668–683.