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## ELECTRICAL ANESTHESIA. VI.

*effects of prolonged subconvulsive cerebral electrostimulation on memory, intellectual level, and subjective report of pain*

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THE TECHNICS of electrically-induced analgesia (EA) for major surgical intervention in human subjects has been reported,<sup>1-4</sup> but no quantified reports have appeared on the effect of EA on the psychologic functions of memory, intelligence, and perceived pain. In the absence of such reports, the literature on the effect of electroconvulsive shock on intellectual functioning and memory will be surveyed since it most closely approximates the EA situation.

Clinical studies based upon observation of patients during and after electroconvulsive therapy (ECT) suggest that the subject is nonreactive to environmental stimuli immediately after the induction of the grand mal convulsion. Perseveration and retrograde amnesia are the major signs noted when psychologic function returns. Hoch and Penes,<sup>5</sup> in reviewing the ECT literature, report that after "an individual ECT, amnesia for pretreatment events is gradually restricted to the period immediately prior to treatment. Repeated seizures produced by any technique result in the development of cumulative organic mental symptoms."

*Intellectual Impairment in ECT* — Psychologic studies of intellectual impairment suggest that the time interval between ECT administration and post-ECT testing may be a major variable. Stone,<sup>6</sup> using alternate

forms of a memory scale with an experimental and a control group of patients, found a significant memory decline in 6 of 7 subtests for the experimental group, while the control group gained significantly in the 3-week interval. In addition, Michael<sup>7</sup> indicated that word-naming showed an immediate post-ECT decline, but gradually rose over time for his experimental subjects. On the other hand, a slight improvement on two intelligence functioning scales from preshock levels has been reported by Huston and Locher.<sup>8</sup> In summary, studies of intellectual function have shown either an immediate post-ECT decline with a gradual recovery of function or no decrement.

*Memory and Retention* — Psychologic studies of memory and retention after ECT have generally confirmed the clinical phenomenon of retrograde amnesia. Using a paired associates learning task, Zubin and Barrera<sup>9</sup> found that, after shock, the more recent associations no longer have the advantage in terms of number remembered that they had before shock. Janis,<sup>10</sup> using a careful anamnestic approach, found universal loss of personal history details for post-ECT patients for as long as 3½ months in some cases, while his non-ECT controls rarely showed such circumscribed amnesias. Carter<sup>11</sup> also found loss of more recent memories.

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Supported by Army Contract No. DA-49-007-MD-627.

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Opinion on the relationship between the properties of electrical stimulus and memory impairment is divided. One view holds that memory disturbance is a consequence of the generalized seizure and that other properties of the eliciting electrical stimulus are of little importance.<sup>12,13</sup> The other view maintains that to a great extent the disturbance is an effect of the electrical stimulation and is determined by the energy of the stimulus.<sup>14</sup> Ottosson,<sup>15</sup> in one of the more carefully designed studies of ECT effects, concluded that a major part of memory disturbances due to ECT is accounted for by effects of electrical stimulation other than seizure activity.

Because the above references concern electroconvulsive shock as a psychiatric therapy using psychiatric patients as subjects, relating intellectual impairment and memory dysfunction to ECT is questionable, since abnormalities of brain function and memory have long been attributed to this class of patients. In addition, Campbell,<sup>16</sup> in his extensive review of the psychological effects of cerebral electroshock, comments, "At present, largely because of methodological weaknesses, the psychological findings do not lend themselves to any exact specifications of the changes wrought by ECT. It seems fair to conclude that, in this instance, the clinical observations have been confirmed but have not been refined."

#### METHOD

Of special concern in our studies is the relationship between brain dysfunction and duration of the electrostimulus to the head. Although below the convulsive threshold,

the duration of the electrostimulation delivered to the subjects reported in this paper is as much as 10,000 joules (watts per hour) greater than the electrical stimuli given for ECT. The continuous delivery of the current lasted for as long as 2 hours as contrasted with the several seconds duration of the electrical stimulus in ECT.

This paper reports data derived from preoperative and postoperative psychologic testing as well as immediate postoperative interviewing. The focus of the testing was measurement of possible organic changes reflected by intellectual functioning and immediate memory. The object of the interview was to determine by nonleading inquiry the operative experience of the patients and especially to determine any noxious or painful sensations they could recall.

*Subjects* — The subjects consisted of 2 groups: 9 operated patients and 5 volunteers who endured a sham operative procedure, and served as a control group.

The operated sample consisted of 7 Negroes (5 female and 2 male) and 2 male Caucasians, ranging in age from 41 to 73 years with a median age of 59. Formal education ranged from none to the 9th grade, with a median of 6 years. All operated subjects experienced major surgical intervention consisting of simple or radical mastectomies for the 5 women and, for the men, a gastrotomy, extensive skin grafting, exploratory laparotomy, and simple mastectomy. Carcinoma was suspected in 3 of the 9 operated subjects.

The 5 male Caucasian volunteers ranged

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from 23 to 37 years of age with a median age of 25. Their educational attainment ranged from 12 to 14 years with a median of 12 years. All were in good physical health and, while all experienced the effects of the electrical stimulus in the operating room, only two had "surgery:" cases 4 and 5, described by Fabian and associates.<sup>3</sup>

**PROCEDURE**

*Anesthetic Delivery*—For a complete description of the anesthetic method, see Hardy and associates<sup>1</sup> and Fabian and associates.<sup>2,3</sup> To summarize briefly: In addition to the usual preparations for chemical anesthetics, a muscle relaxant was injected and a tube inserted into the trachea of each operated subject. The relaxant was used to control generalized muscle spasms which result from the current, and the endotracheal intubation to provide an avenue by means of which respiration, the normal processes of which were inhibited by the muscle relaxant, could be manually controlled. The electrical stimulus was delivered as a sinusoidal current with a frequency of 700 cps, a voltage range of 12 to 47, and a milliamperage range of 50 to 110 milliamperes. During surgery, the electrical stimulus was delivered continuously for a median of 60 minutes (range 20 to 240 minutes). For the "sham controls," the electricity was delivered for a median of 25 minutes.

*Intelligence and Memory Testing*—The initial phase of the testing consisted of giving the complete Wechsler Adult Intelligence Scale<sup>17</sup> (WAIS) and the Graham-Kendall Memory-for-Designs Test<sup>18</sup> (MFDT) within the 24-hour period prior to EA administration. High scores on the MFDT are related to brain dysfunction. Within 62 hours following EA, the complete Wechsler-Bellevue-Form II (WB-II)<sup>19</sup> and a repeat MFDT were administered.

*Post-Test Interview* — As soon after the cessation of the EA as feasible (about 15

minutes) one of us conducted a nonleading inquiry with the operated sample. The interview was aimed at establishing the alertness of the subjects and eliciting recall of the events during the operation.

**RESULTS AND DISCUSSION**

Evaluation of the grouped Wechsler Scale data (table) reveals no evidence of IQ decrement in Verbal, Performance, or Full Scale Scores for operated subjects or controls when the pretest scores are compared with post-test findings. On the contrary, slight *gains* in Full Scale IQ score for 8 of the 9 operated subjects and for all 5 controls were found, suggesting mild practice effects.

A Wilcoxon Matched-Pair Signed-Ranks test run on the MFDT paired scores for both operated and control groups yields probability values which fail significance at the 0.05 level, indicating no significant change in memory for geometric designs as a function of EA and therefore no test evidence of brain insult.

The post-EA interview revealed almost complete analgesia for the surgical incisions on the subjects interviewed. Unless given additional chemical anesthetic agents, the subjects were alert and aware of surroundings immediately after the current was turned off. The subjects were well oriented for time, place, and person, and showed little of the confusion reported by investigators of post-ECT subjects.<sup>5</sup> When asked to describe "anything they felt" while on the operating table, all mentioned the "buzzing" or "whirring" in their heads, which was usually not described as *painful* but rather as unpleasant. In addition, the nasotracheal tube was described as irritating. The more vocal volunteers complained of rather severe apprehension concerning the fact that they were unable to breathe spontaneously and knew that they must rely on the anesthesiologist's control of respiration. The re-



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**Table**  
**MEAN WECHSLER I.Q. SCORES**

	Experimental group (operated) N=9		Control group (nonoperated) N=5	
	Pre-EA (WAIS)	Post-EA (WB-II)	Pre-EA (WAIS)	Post-EA (WB-II)
Verbal I.Q.	77.0	81.9	103.0	110.4
Performance I.Q.	73.1	75.6	111.2	119.2
Full Scale I.Q.	74.8	79.3	107.4	115.8

called pain at the operative site was described in such terms as "pricking" and "pinching," and "itching" attributed to surgery involving extensive skin grafting, major radical mastectomy, and exploratory laparotomy.

The findings do not give evidence of measurable intellectual decrement or memory loss. They tend to support the view that the convulsive threshold must be crossed to disrupt cortical functioning. Despite the subjects' retention of consciousness during the operative procedure, analgesia for the surgical act was fair. Stimuli attendant to the initiation of the current and to maintenance of breathing were recalled as more unpleasant than the incisions themselves.

### SUMMARY

The application of a continuous ( $\frac{1}{2}$  to 2 hours) subconvulsive electric current to the head as a means of inducing surgical analgesia provided an opportunity for measuring current effects on (1) intellectual functioning and (2) immediate memory as well as (3) obtaining a subjective verbal report of the experience immediately thereafter. Fourteen subjects, 9 operative cases and 5 nonoperative volunteers, took the Wechsler Adult Intelligence Scale and Graham-Kendall Memory for Designs Test (MFD) prior to application of the electrical stimulus, while the Wechsler Bellevue Form II and a repeat MFD were administered following the electrical stimulus. Comparison of pre-stimulus and poststimulus score differences proved nonsignificant, suggesting no measurable stimulus effect on either intellectual functioning or immediate memory. The immediate poststimulus interview suggested that the subjects were alert and well oriented, reporting little of the confusion typical of post-ECT patients. The postoperative subjects described the electrical stimulus as a "buzzing" or "whirring" sensation in the head which was not experienced as painful but rather as unpleasant. Terms such as "pricking," "pinching," and "itching" were commonly used in descriptions of the major surgical procedures, suggesting some analgesic effectiveness. Support for the view that the convulsive threshold must be crossed to disrupt cortical functioning is provided.

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