

## Should They Be Reevaluated?

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*An investigation of two widely used ECT machines has shown that in one instance the instrument did not meet the manufacturer's specifications, and in both cases ordinary use may increase the possibility of delivering currents which exceed minimal levels necessary to produce a seizure. In the interests of accuracy, efficacy, and sound clinical practice, it is suggested that ECT machines be provided with automatic voltage and timing devices and that professional regulation of such machines be established.*

IN REVIEWING the literature on electroconvulsive therapy (ECT) for a textbook on psychiatric treatment, one of us (T.P.D.) could not find a single publication documenting that commercially available ECT units in the United States in fact meet the specifications claimed by their manufacturers. Because it is good clinical practice to give minimal effective doses of any treatment, we investigated, both under clinical conditions and in the laboratory, characteristics of current delivered by several versions of two commonly used ECT instruments, the Reuben Reiter MOL-AC II and the Medcraft Model B24.

### Methods

Records were taken during six ECT treatments administered to a single patient at the Yale-New Haven Hospital. The patient was premedicated with atropine and lightly anesthetized with thiopental sodium, followed by intravenously administered succinylcholine to provide muscle relaxation. ECT was administered immediately after muscle fasciculation subsided and current was delivered to the patient

through temporal electrodes moistened with saline. The amount and duration of current passed during each treatment were measured with a storage oscilloscope (Tektronix RM564). The differentially amplified voltages across a 10-ohm ( $\pm 0.5\%$ ) precision resistor in series with the patient's electrodes were displayed oscillographically; the height of the vertical deflection of this oscilloscope trace was, by Ohm's law, directly proportional to current passing through the patient's electrodes. The voltage across the electrode terminals of the ECT unit was measured simultaneously with the current through high impedance probes (Tektronix P6006) and displayed on the second trace of the oscilloscope; care was taken to prevent any leakage of current through inadvertent ground paths. The oscilloscope's sweeps were usually triggered by the beginning of the electrical shock applied to the patient. The stored oscillographic record was photographed following each treatment.

In addition, the ECT units themselves were subjected to examination in an electrophysiology laboratory. The values of current and voltage stated in the text are root-mean-squares.

### Results

**Clinical Results.**—The clinical results, although reported for a single patient, include a variety of measurements using different ECT machines and different parameters of stimulation. During the six treatment sessions, the various ECT machines used delivered 109 to 135 v at 60 Hertz units across the temporal electrodes. The electrode impedance during ECT ranged from 380 to 580 ohms. The electrode resistance measured with a vacuum tube voltmeter, ie, when negligible current was passed, was approximately 1,800 ohms. Because of the low electrode impedance during ECT, the current passed was high, ranging from 200 to 360 ma, though how much of this current actually traversed brain tissue is unknown.

Convulsions were produced in all cases. The minimum amount of

current required to produce a convulsion using a Medcraft Model B24 is shown in Fig 1: 200 ma for 80 msec. This corresponds to a minimum energy requirement somewhat less than that indicated by Maxwell.<sup>1</sup> Despite efforts to minimize the intensity and duration of ECT, during the treatment shown in Fig 2—using a Reuben Reiter MOL-AC II—more than one-half again as much current was passed than for the treatment depicted in Fig 1, for almost ten times as long: 360 ma for approximately 750 msec.

**Reuben Reiter MOL-AC II.**—Three separate units were tested, each consisting of a transformer, a three-position intensity switch, pushbutton, and pilot light. Some models included an on-off switch. Other than that, the three models were essentially the same. Voltage is applied to the electrode output terminals when the push button is depressed. The manufacturer's brochure indicates that after the button is depressed the current automatically drops so that it is safe to hold it down. Yet no automatic timing circuit was found in any of these machines, as can be seen from the circuit of a typical unit shown in Fig 3. While the physician may believe that current markedly drops during treatment, we in fact found a slightly increasing current during ECT administered with this instrument (Fig 2). Because the timing is controlled by keeping the button depressed, it is extremely difficult to administer, reliably, treatments of durations of fractions of a second, although fractional-second ECT is often sufficient to induce convulsions.<sup>1</sup>

A pilot lamp (Fig 3) on this unit is covered by a cowl which may be rotated and, indeed, the lamp appears dim or bright depending on the direction of rotation. The cowl is not, however, connected to anything inside the unit; thus, it is essentially a meaningless

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control. Furthermore, as can be seen from Fig 3, the lamp is tapped from the primary side of the transformer, so that the only information it can convey is that the unit is plugged in and the fuse is intact.

The open circuit output voltages at the high, medium, and low positions, with an input voltage of 110 v, were, respectively, 195, 179, and 155 v. With a load of 370 ohms—that is, in the range of the actual electrode impedance during treatment—the output voltages were, respectively, 121, 117, and 107 v. This is a rather narrow range of output voltages, similar to the range of fluctuation in unregulated voltage available from an ordinary wall outlet. It seems unlikely that the voltage selection in this instrument has any practical medical usefulness.

**Medcraft Model B24.**—This unit is more complicated than the MOL-AC II. It consists of elements similar to those in the MOL-AC II, plus a timer and potentiometer with a spring wind-up. The machine can be used in two modes: with or without “glissando” (gradually rising current). Treatment is initiated by depressing a button. In the nonglissando mode, the duration and voltage of the treatment can be controlled automatically. The duration controls may be varied from 0.1 second to 1 second in eight steps. The voltage control ranges from 70 v to 170 v in 11 steps. Both of these controls were found to be accurate within reasonable limits. With a load of 400 ohms, at the 170, 120, and 70 voltage settings, for instance, the output voltages were, respectively, 157, 114, and 68 v.

In the glissando mode, current passes through a potentiometer which is wound down by a spring during the treatment. A noise-maker—a copper vane which bangs against the side of the box—is attached to the spring so that a clanging noise is heard while the

potentiometer winds down. Figure 4 shows the glissando of current produced by this apparatus. The current rises smoothly for 0.9 seconds to the preset voltage. This voltage is then maintained for the preset time. Because the glissando takes 0.9 second no matter what the preset time is, and because, without glissando, a convulsion may begin in less than 0.1 second (Fig 1), when the glissando is used, the total amount of energy dissipated within the patient may be more than three times larger than necessary. (This ratio of three was calculated by dividing the approximate integral of the minimum energy dissipated during use of the glissando by the energy dissipated during a 0.1-second treatment in the nonglissando mode, assuming a constant output impedance and the same final voltages in both cases.)

#### Comment

The necessity of delivering enough current to produce a tonic-clonic seizure to obtain optimal therapeutic effectiveness with ECT seems well established. In order to avoid the potential hazards of suprathreshold currents described by Ottosson,<sup>2</sup> however, it would seem advantageous to deliver the *minimum* current necessary to produce a seizure. (Although remarkably little has been published regarding the long-term effects of ECT on mental functioning, Janis and Astrachan<sup>3</sup> found memory impairment “four weeks or more after the last electroshock treatment at a time when the ‘organic’ impairment syndrome which occurs during the treatment period had already cleared up.” Some memory impairments persisted for at least one year following the last treatment [I. L. Janis, oral communication, 1968].) This minimal current must be determined individually for each patient.

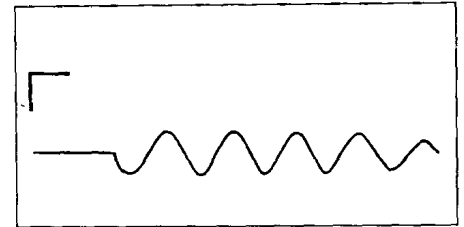


Fig 1.—Record of minimal ECT delivered with a Medcraft Model B24 instrument set in the nonglissando mode; 120 volts, 0.1 second. Trace is retouched. Calibration: vertical, 500 ma; horizontal, 10 msec.

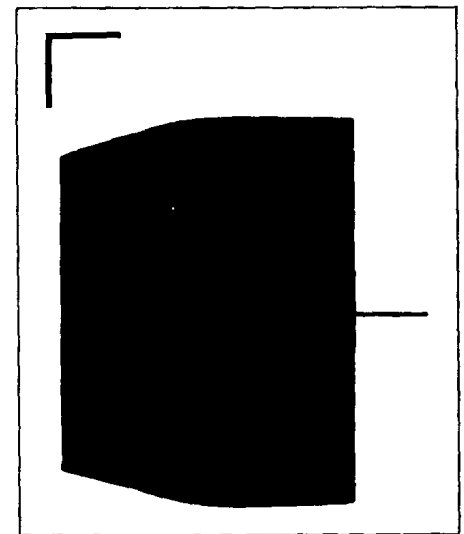


Fig 2.—Typical record of ECT with a Reuben Reiter MOL-AC II instrument set on high voltage range. Trace is retouched to show only envelope of peak-to-peak, 60 Hz current. Note that current does not decrease but slightly increases during treatment. Calibration: vertical, 200 ma; horizontal, 200 msec.

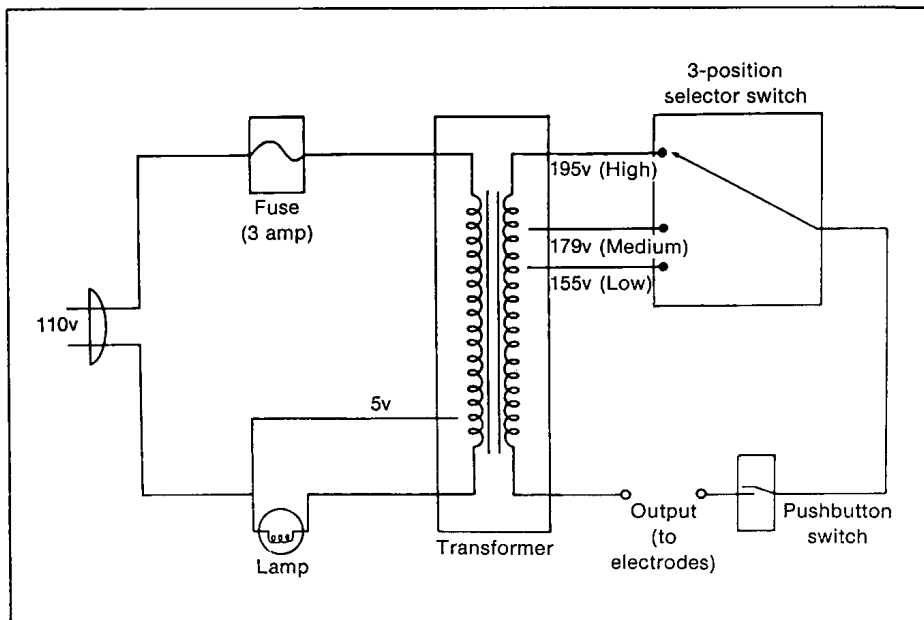


Fig 3.—Schematic diagram of the electrical circuit of a Reuben Reiter MOL-AC II. All voltages are alternating current. Output voltages are measured at impedance equals infinity ( $Z = \infty$ ) (open circuit).

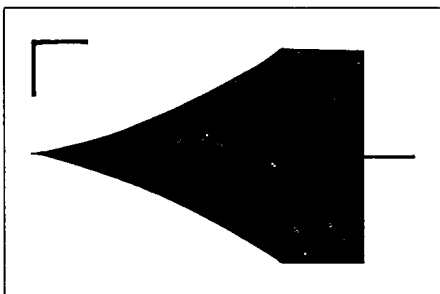


Fig 4.—Record of current passed by a Medcraft Model B24 instrument through a load of 400 ohms to demonstrate the glissando. The instrument was set at 140 v; glissando, plus 0.4 seconds. Trace is retouched to show only envelope of peak-to-peak, 60 Hz current. Calibration: vertical, 250 ma; horizontal, 200 msec.

**Reuben Reiter MOL-AC II.**—Our analysis indicates to us that close regulation and control of current is not possible with an unmodified MOL-AC II instrument. While Impastato et al<sup>4</sup> reported a rapid decrease in output voltage within about 1 msec of the beginning of an ECT treatment, we could find no evidence that an initial high current surge is followed automatically by a decreased current.

**Medcraft Model B24.**—We find the Medcraft Model B24 provides accurate control over the voltage and duration of treatment. This is useful; we found it much easier to obtain minimal durations and intensities of current by relying on automatic timing than by clinical observation of seizure onset, as recommended in the manufacturer's instructions for the MOL-AC II.

The "glissando" was ostensibly introduced to provide slower onset of seizure and thereby reduce bone fracture during treatment. Evi-

dence for its effectiveness is not, however, conclusive. Moreover, with use of muscle relaxant such as succinylcholine this technique has become, in our view, obsolete and perhaps even disadvantageous as the glissando mode may unduly prolong the duration of ECT.

We suggest that all ECT instruments be provided with automatic regulation of voltage and impulse duration, as available with the Medcraft Model B24. Moreover, the manufacturer's specifications should be accurate. Perhaps some means of regulation of such products (eg, by the Food and Drug Administration) would be appropriate.<sup>5</sup> Joint efforts of health professionals to set up appropriate procedures for the evaluation of medical equipment seems to us a desirable move. Such a step is a prerequisite for the formulation of adequate safety standards, safeguarding the interests of all.

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