Seizure Threshold in ECT: II. Dose Titration *vs* Age and Half Age Methods†

WORRAWAT CHANPATTANA, M.D.*, SOMCHAI CHAKRABHAND, M.D.**,
PISARN TECHAKASEM, M.D.***, SUNEE RAKSAKIETISAK, Ph.D.****

Abstract

Seizure threshold determination is of crucial importance in optimizing electrical stimulus dosage at electroconvulsive therapy (ECT). We measured initial seizure threshold by means of Srinakharinwirot University titration schedule in 106 patients with schizophrenia or schizo-affective disorder, receiving bilateral ECT. Seizure threshold was approximately 106 milli-coulombs on average, and varied 5-fold across patients. Seizure threshold was directly related to age, but inversely related to motor seizure duration. Comparisons of stimulus charge were done with the Age and Half age methods. By using the Half age method, 68 per cent of patients would have seized at the first stimulation and resulted in a closer mean charge to dose-titration method than the Age method. The results may have important clinical implications for stimulus dosing strategy in ECT.

Key word : Electroconvulsive Therapy (ECT), Schizophrenia, Initial Seizure Threshold, Srinakharinwirot University Titration Schedule, Dose-Titration *vs* Age and Half Age Methods

CHANPATTANA W, et al
J Med Assoc Thai 2000; 83: 278-283

In practice, optimization of ECT is to insure that each patient has an adequate seizure at each treatment by using a minimum dosage of electrical stimulus charge. Recent work indicates that this central belief is wrong, both the efficacy and the cognitive side effects of ECT depend on the extent to which the stimulus dosage exceeds the patient's seizure threshold[1-7].

* Department of Psychiatry, Srinakharinwirot University,
** Srithunya Hospital, Bangkok 11000,
*** Vajira Hospital, Bangkok 10300,
**** Department of Mathematics, Srinakharinwirot University, Bangkok 10300, Thailand.
† Supported by The Thailand Research Fund, grant BRG 3980009.

Recent studies suggest a wide range in initial seizure threshold, varying from a low of 4-fold[8,9] to a high of 40-fold[5]. Factors influencing the threshold include age[10], electrode placement[11], gender[12], anesthetic agents[5], concurrent medications[5,13], and method of measurement[14,15]. Therefore, optimizing stimulus dosage during ECT requires seizure threshold determination for the individual patient[16].

Dose-titration method, recommended by the APA Task Force on ECT[16], offers the most proven advantages in estimating seizure threshold [17]. However, criticism has been made on its inconvenience in routine practice and cardiovascular risks secondary to repeated subconvulsive stimulations. An alternative approach, suggested to avoid the cumbersome method and its associated risks, is the use of preselected stimulus dose including Age method[10] and recently Half age method [18].

We report a comparison of three methods for selecting electrical stimulus dosage for ECT. The three methods include dose-titration, Age, and Half age methods.

METHOD

Subjects

The subjects included 106 patients with DSM-IV[19] schizophrenia (n = 97) or schizoaffective disorder (n = 9) received ECT at the participating hospitals. Patients were excluded who had received either ECT or depot neuroleptics within the prior six months and were taking medicines with anticonvulsant properties (e.g., antiepileptics, benzodiazepines, beta-blockers).

All psychotropic medicines were discontinued at least 5 days prior to the first ECT, except flupenthixol 12 mg/day and benzhexol (4-6 mg/day). No other medicines were prescribed.

ECT technique

ECT was administered three times per week. An ECT device was a MECTA SR1. Thiopental (2-4 mg/kg) was used as anesthesia at the lowest dosage to minimize effect on seizure threshold. Succinylcholine (0.5-1 mg/kg) served as the muscle relaxant. Atropine sulfate (0.4 mg intravenously) was administered just before anesthesia. Patients were hyperventilated from the time of administration of anesthesia until postictal resumption of spontaneous respiration. The bitemporal bilateral electrode placement was used throughout. The tourniquet method and two channels of prefrontal electroencephalogram (EEG) were used to assess seizure duration.

Determination of initial seizure threshold

Seizure threshold was defined as the lowest electrical stimulus charge that produced an adequate seizure, defined as a motor seizure occurring bilaterally for at least 30 seconds plus EEG evidence of cerebral seizure. Seizure threshold was quantified at the first two treatment sessions by our titration schedule (Table 1). At the first session, the first level of stimulus intensity (10% of the maximum charge) was administered to all patients. If this failed to elicit such a seizure, the patient was then stimulated with an electrical charge one level higher and up to 4 stimulations were used with an interval of at least 40 seconds between each. Additional thiopental was not given. At the second session, the patient was stimulated with a stimulus charge 5 per cent lower than the first session. If this failed to elicit adequate seizure, the previous value was adopted as the patient's seizure threshold; whereas if an adequate seizure could be elicited, this new value was used instead.

Comparison with Age and Half Age methods

Seizure threshold, estimated by our dose-titration method (DTM) in units of charge (mC), was compared with the stimulus charge that would have been selected if the Age and Half age methods (AM & HAM) had been used.

Statistical analysis

Seizure threshold was logarithmically transformed to improve normality of the data distribution. Differences between groups on single, continuous variables were evaluated with *t*-tests or analysis of variance (ANOVA). The degree to which variables could predict seizure threshold was examined by stepwise multiple regression analysis. Before inclusion in the multivariate model, the relationship between each variable and seizure threshold was investigated by the Pearson's product-moment correlation. Values are given as mean $\pm$ SD.

RESULTS

Seizure threshold quantified by our titration schedule was 105.7 $\pm$ 45.4 mC. There was a substantial variability in patient's threshold, the

Table 1. Srinakharinwirot University dosing schedule for MECTA SR1.
Initial and successive treatments (25-100% increments).

Level*	Pulse width	Frequency	Duration	Current	Charge (mC)	%
1	1.0	40	1.25	0.6	60	10
2	1.0	40	2.0	0.75	120	20
3	1.0	60	2.0	0.75	180	30
4	1.2	60	2.0	0.8	230.4	40
5	1.0	90	2.0	0.8	288	50
6	1.4	90	2.0	0.8	403.2	70
7	2.0	90	2.0	0.8	576	100
Extra level**						
1	1.0	40	0.5	0.8	32	5
2	1.0	40	1.5	0.7	84	15
3	1.0	90	1.0	0.8	144	25
4	1.0	60	2.0	0.8	192	35
5	1.2	70	2.0	0.75	252	45
6	1.2	90	2.0	0.8	345.6	60
7	1.6	90	2.0	0.8	460.8	80
8	1.8	90	2.0	0.8	518.4	90

* Increase by one level (25-100% increment) is recommended for use in eitherdose titration at the first treatment or subsequent treatments.

** The extra level is used at the second treatment session.

Table 2. Seizure threshold as a function of age and sex (millicoulombs).

Groups	Female	Male	P value
≤ 30 years			
mean ± SD	96.0 ± 32.6 (n = 20)	91.2 ± 35.8 (n = 16)	NS
range	60-180	60-180	
31-40 years			
mean ± SD	100.8 ± 32.6 (n = 15)	112.8 ± 35.4 (n = 22)	NS
range	60-180	60-180	
> 40 years			
mean ± SD	138.8 ± 49.3 (n = 20)	150.2 ± 56.2 (n = 13)	NS
range	60-230.4	60-288	
All	112.9 ± 43.6 (n = 55)	116.0 ± 49.0 (n = 51)	NS

NS : no statistical significance

range observed was from 60 mC to 288 mC. Seizure threshold of males (116.0 ± 49.0 mC, n = 51) was almost equal to female patients (112.9 ± 43.6 mC, n = 55; $F = 0.12$, $p = 0.73$). Table 2 shows the threshold values as a function of age and sex.

One hundred and five patients seized at the first session. The numbers of patients who seized at each level (1- 4) of stimulations was 24 (23%), 56 (53%), 22 (21%), and 3 (3%), respectively. One patient seized at the second session using 288 mC. Seizure threshold could be determined at the first session in the majority of patients (74%, n = 78), and the rest (26%) could be quantified at the second session. Average number of stimulations was 2.1 ± 0.8. Anesthetic procedure required 150.1 ± 38.0 mg of thiopental and 24.5 ± 6.4 mg of succinylcholine.

Only age had a strong relation with seizure threshold ($r = 0.33$, $p < 0.0001$) which accounted for 11.2 per cent of variance predicting the threshold.

Table 3. Comparison of titration with age and half-age methods and number of patients who would have failed to seize by age and half age methods.

Groups	Titration (actual threshold)	Age method (AM) predicted value	failed AM	Half-age method (HAM) predicted value	failed HAM
< 30 years (n = 36)	88.2 ± 43.3	168.9 ± 19.0[a]	0	80.3 ± 7.1	17 (47%)
31-40 years (n = 37)	103.2 ± 40.2	222.1 ± 13.2[b]	0	114.5 ± 8.8[c]	9 (24%)
> 40 years (n = 33)	125.9 ± 45.7	287.1 ± 28.0[d]	1	144.2 ± 15.3[e]	8 (24%)
All (n = 106)	105.7 ± 45.4	225.9 ± 52.3[f]	1	113.0 ± 28.1	34 (32%)

* given in mean ± SD (millicoulombs).
a t = 9.78, df = 1,35, p < 0.0001
b t = 12.79, df = 1, 36, p < 0.0001
c t = 2.46, df = 1,36, p = 0.019
d t = 14.42, df = 1,32, p < 0.0001
e t = 2.37, df = 1,32, p = 0.024
f t = 20.73, df = 1,105, p < 0.0001

Comparison of DTM with AM and HAM

Table 3 presents the stimulus charge obtained by three methods, and the number and percentage of patients who would have failed to seize at the first stimulation if the stimulus intensity selected by AM and HAM had been used in each age group.

DTM consistently resulted in lower stimulus charge than either of AM and HAM. In all age groups, there was a significant difference between DTM and AM but not between DTM and HAM. For patients ages ≤ 30, there was only a significant difference between DTM and AM; but for patients ages > 30, the differences were much larger between DTM and AM than that of DTM and HAM.

By using HAM in selection of stimulus charge, almost half of the patients aged ≤ 30 and 24 per cent of patients in each of the two other groups would have failed to seize. An overall success rate in eliciting an adequate seizure by using stimulus charge of the HAM's protocol would have been 68 per cent, and increased to 76 per cent in patients aged > 30. On the contrary, if the stimulus charge selected by the AM's protocol had been used only one patient would have failed to seize.

DISCUSSION

In our study of a clinical sample of 106 psychotic patients who received treatment with a brief-pulse, constant current, bilateral ECT, we found that the average initial seizure threshold was 105.7 ± 45.4 mC. This estimate is in the middle of the range of mean thresholds observed by other investigators using DTM[5,8,11,12,20,21]. The range in threshold values observed in our study was from 60 mC to 288 m C (5-fold).

Regarding factors that influence seizure threshold, we found that only age had a strong relationship with the threshold, other variables did not. Our findings may be explained by using either a relatively high dosage of thiopental compared to other studies[2-4], only bilateral electrode placement, or concomitant neuroleptic[22].

It is clear that average seizure threshold represents an approximation, while the real threshold values are actually somewhere below that dosage level. We attempted to quantify the patient's seizure threshold twice instead of only once as in other studies, in order to obtain a more precise value. However, only 26 per cent of patients (n = 28) had their new threshold values at the second session.

The overall success rate of HAM in eliciting an adequate seizure would have been 68 per cent, and increased to 76 per cent in patients aged > 30 in our clinical sample of 106 patients. The result is impressive and treating psychiatrists can avoid the cumbersome method with DTM and spend less time in administering bilateral ECT in clinical use. The majority of patients bypass any untoward effects of using multiple subconvulsive stimulations. Although using the electrical stimulus dosage of AM's protocol would have resulted in successful stimulation at the first attempt in nearly

all of our patients, the method has been criticized for delivering higher-than-needed stimulus intensity with the likely consequences on cognitive functions.

In summary, at the present time DTM is the best-established method in estimating a patient's seizure threshold. Using electrical stimulus dosage of the Half-age protocol offers a more convenient use in clinical practice.

ACKNOWLEDGEMENT

This study was supported by the Thailand Research Fund, grant BRG 3980009.

(Received for publication on April 20, 1999)

REFERENCES

1. Sackeim HA. Not all seizures are created equal: The importance of ECT dose-response variables. Behav Brain Sci 1984; 7: 32-3.
2. Sackeim HA, Decina P, Kanzler M, et al. Effects of electrode placement on the efficacy of titrated, low dose ECT. Am J Psychiatry 1987a; 144: 1449-55.
3. Sackeim HA, Decina P, Malitz S, et al. Seizure threshold in electroconvulsive therapy. Arch Gen Psychiatry 1987b; 44: 355-60.
4. Sackeim HA, Decina P, Portnoy S, et al. Studies of dosage, seizure threshold, and seizure duration in ECT. Biol Psychiatry 1987c; 22: 249-68.
5. Sackeim HA, Devanand DP, Prudic J, et al. Stimulus intensity, seizure threshold, and seizure duration: Impact on the efficacy and safety of electroconvulsive therapy. Psychiatr Clin North Am 1991; 14: 803-43.
6. Sackeim HA, Prudic J, Devanand DP, et al. Effects of stimulus intensity and electrode placement on the efficacy and cognitive side effects of electroconvulsive therapy. N Engl J Med 1993; 328: 839-46.
7. Abrams R, Swartz CM, Vedak C. Antidepressant effects of high-dose right unilateral electroconvulsive therapy. Arch Gen Psychiatry 1991; 48: 746-8.
8. Weiner RD. ECT and seizure threshold: Effects of stimulus waveform and electrode placement. Biol Psychiatry 1980; 15: 225-41.
9. Beale MD, Kellner CH, Pritchett JT, et al. Stimulus dose-titration in ECT: A 2-year clinical experience. Convulsive Ther 1994; 10: 171-6.
10. Abrams R, Swartz CM. ECT instruction manual. 3rd ed., Somatics Inc., 1989.
11. Enns M, Karvelas L. Electrical dose titration for electroconvulsive therapy: A comparison with dose prediction methods. Convulsive Ther 1995; 11: 86-93.
12. Coffey CE, Lucke J, Weiner RD, et al. Seizure threshold in electroconvulsive therapy: I. Initial seizure threshold. Biol Psychiatry 1995; 37: 713-20.
13. Standish-Barry HMAS, Deacon V, Snaith RP. The relationship of concurrent benzodiazepine administration to seizure duration in ECT. Acta Psychiatr Scand 1985; 71: 269-70.
14. Abrams R. Stimulus parameters and efficacy of ECT: Commentary. Convulsive Ther 1994; 10: 124-8.
15. Sackeim HA. Physical properties of the ECT stimulus. Convulsive Ther 1994; 10: 140-52.
16. American Psychiatric Association. The practice of electroconvulsive therapy: Recommendations for treatment, training, and privileging. A Task Force Report. Washington, DC, APA, 1990.
17. Beyer JL, Weiner RD, Glenn MD. Electroconvulsive therapy: A programmed text. 2nd ed., Washington, DC, American Psychiatric Press, 1998.
18. Petrides G, Fink M. The "half-age" stimulation strategy for ECT dosing. Convulsive Ther 1996; 12: 138-46.
19. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th ed., Washington, DC, APA, 1994.
20. Weaver L, Ives J, Williams R, et al. The threshold number of pulses in bilateral and unilateral ECT. Biol Psychiatry 1978; 13: 227-41.
21. Shapira B, Lidsky D, Gorfine M, et al. Electroconvulsive therapy and resistant depression: Clinical implications of seizure threshold. J Clin Psychiatry 1996; 57: 32-8.
22. Janowsky EC, Risch SC, Janowsky DS. Psychotropic agents. In: Smith NT, Corbascio AN (eds.). Drug interactions in anesthesia. 2nd ed., Philadelphia, Lea and Febiger, 1986: 261-81.

ปริมาณไฟที่เหมาะสมในการรักษาด้วยไฟฟ้า: II. การศึกษาเปรียบเทียบระหว่างวิธีการมาตรฐานและการใช้ค่าตามอายุและค่าครึ่งอายุ†

วรวัฒน์ จันทร์พัฒนะ, พ.บ., สมชาย จักรพันธ์, พ.บ.**,*
*พิสาส์น เตชะเกษม, พ.บ.***, สุณี รักษาเกียรติศักดิ์, ปร.ด.*****

การหาปริมาณไฟที่เหมาะสมที่ใช้ในการรักษาด้วยไฟฟ้าเป็นสิ่งที่มีความสำคัญมากในการให้ได้ประสิทธิภาพการรักษาสูงสุดและเกิดผลข้างเคียงน้อยที่สุด คณะผู้วิจัยได้ทำการศึกษาเปรียบเทียบการหาปริมาณไฟที่เหมาะสมโดยใช้วิธีการมาตรฐานกับการใช้ค่าตามอายุและการใช้ค่าครึ่งอายุในการรักษาด้วยไฟฟ้าในผู้ป่วยโรคจิต 106 คน

พบว่าค่าเฉลี่ยของปริมาณไฟที่เหมาะสมในการเริ่มต้นการรักษามีค่าเท่ากับ 106 มิลลิคูลอมบ์ ปริมาณไฟในการเริ่มต้นการรักษามีค่าแตกต่างกัน 5 เท่า ค่าปริมาณไฟแปรผันตรงกับอายุผู้ป่วย เมื่อเปรียบเทียบปริมาณไฟที่ได้จากการใช้วิธีมาตรฐานกับวิธีการใช้ค่าตามอายุและค่าครึ่งอายุ พบว่าการใช้ปริมาณไฟตามค่าครึ่งอายุสามารถกระตุ้นผู้ป่วยได้ถึงร้อยละ 68 และมีค่าเฉลี่ยใกล้เคียงกับค่าที่ได้จากวิธีมาตรฐาน ส่วนการใช้ปริมาณไฟตามค่าอายุสามารถกระตุ้นผู้ป่วยได้ถึงร้อยละ 99 (105 คน) แต่มีค่าเฉลี่ยสูงกว่าค่าที่ได้จากวิธีมาตรฐานมาก

การใช้วิธีมาตรฐานสามารถหาปริมาณไฟที่เหมาะสมในการรักษาด้วยไฟฟ้าได้ดีที่สุดแต่ไม่สะดวกในการใช้โดยทั่วไป ส่วนการใช้ค่าครึ่งอายุสามารถใช้ในการรักษาผู้ป่วยได้รวดเร็วและสะดวกกว่ามาก การศึกษานี้มีประโยชน์มากในการเลือกปริมาณไฟที่เหมาะสมในการรักษาด้วยไฟฟ้า

คำสำคัญ : การรักษาด้วยไฟฟ้า, ปริมาณไฟต่ำสุดที่ใช้ในการรักษา, การศึกษาเปรียบเทียบ, โรคจิตเภท

วรวัฒน์ จันทร์พัฒนะ และคณะ
จดหมายเหตุทางแพทย์ ฯ 2000; 83: 278–283

* ภาควิชาจิตเวชศาสตร์, คณะแพทยศาสตร์ มหาวิทยาลัยศรีนครินทรวิโรฒ,
** กรมสุขภาพจิต, กระทรวงสาธารณสุข, กรุงเทพ ฯ 11000
*** โรงพยาบาลวชิรพยาบาล, กรุงเทพ ฯ 10300
**** คณะวิทยาศาสตร์, มหาวิทยาลัยศรีนครินทรวิโรฒ, กรุงเทพ ฯ 10300
† ทุนวิจัยจากสำนักกองทุนสนับสนุนการวิจัย (สกว.)