

A case of schizophrenia successfully treated by m-ECT using 'long' brief pulse

Hiroaki Inomata, Hirohiko Harima, Masanari Itokawa

ABSTRACT

Introduction: Modified-Electroconvulsive Therapy (m-ECT) is administered for the treatment of various psychiatric disorders. The Seizure Generalization Hypothesis holds that propagation of the induced seizure throughout the entire brain is essential for effective ECT intervention. However, there are many clinical cases where, due to high thresholds, seizure is not induced by the maximum dose of electrical charge. Several studies have indicated that the ultrabrief pulse method, in which the pulse width is less than 0.5 millisecond (ms), is more effective for inducing seizures than the conventional brief pulse (0.5-2.0 ms). **Case Report:** A 35-year-old Japanese male schizophrenic with psychomotor excitement was admitted to our hospital. In a series of m-ECT interventions, trials with 1.0 and 1.5 ms width pulses (referred to as 'long' brief pulse as 0.5 ms width pulse is the default in Japan) succeeded in inducing seizures, whereas the ultrabrief pulse failed. **Conclusion:** This case suggests that seizure threshold depends on pulse width. We speculate that in our patient the strength-duration curve involved in ECT-induced seizures

might be right-shifted resulting in prolonged chronaxie to about 1.0 ms. Therefore, in cases where neither the default width pulse nor the ultrabrief pulse induces seizures, patients should be considered for treatment using a wider width pulse.

Keywords: Electroconvulsive Therapy, Pulse width, Chronaxie, Schizophrenia

Inomata H, Harima H, Itokawa M. A case of schizophrenia successfully treated by m-ECT using 'long' brief pulse. International Journal of Case Reports and Images 2012;3(7):30–34.

doi:10.5348/ijcri-2012-07-147-CR-8

INTRODUCTION

Electroconvulsive therapy (ECT) is a psychiatric therapeutic procedure by the use of electricity-induced seizures. It was started in 1930's and had been a main therapeutic technique in psychiatric field until antipsychotic drugs emerged. In addition to the advent of drug therapy, ethical problems in the appearance and the side-effects, which include bone fractures by the convulsion and memory-loss by the over-dosed electricity, reduced the administrations of this therapy. In the famous movie "One Flew Over the Cuckoo's Nest", ECT is described as a torture device for patients. However, ECT has been revalued by the introduction of anesthetic techniques, for example, induction drugs to relieve the patient's scared feelings and muscle relaxants for preventing the limbs and body convulsions and the development of pulse-wave ECT device that can control the dose of charge to be given to the patients.

Hiroaki Inomata^{1,2}, Hirohiko Harima¹, Masanari Itokawa¹
Affiliations: ¹Department of Psychiatry, Tokyo Metropolitan Matsuzawa Hospital, 2-1-1 Kamikitazawa, Setagaya-ku, Tokyo, Japan; ²PHAZOR, LLC, Yokohama, Japan.
Corresponding Author: Hiroaki Inomata, Department of Psychiatry, Tokyo Metropolitan Matsuzawa Hospital, 2-1-1 Kamikitazawa, Setagaya-ku, Tokyo, Japan - 156-0057; Ph: +81-3-3303-7211; Fax: +81-3-3329-7586; Email: inomatah0612@gmail.com

Received: 08 November 2011
Accepted: 25 March 2012
Published: 31 July 2012

Specifically, this new modality using a muscle relaxant is referred to as ‘modified’ ECT (m-ECT).

Nowadays, m-ECT is administered for the treatment of various psychiatric disorders especially, drug-resistant severe depression and schizophrenia with abrupt onset of psychotic symptoms [1]. Although ECT has come to be widely used again, the precise mechanism of its action remains unclear. Many studies in literature and clinical observations suggest that propagation of induced seizure through the entire brain and the seizure lasting for enough time (25 seconds at minimum on monitoring EEG as is often recommended) is essential for effective ECT intervention. This evidence is summarized into ‘The Seizure Generalization Hypothesis’ [2]. However, there are many clinical cases where, due to high thresholds, seizure is not induced by the maximum dose of electrical charge. In these cases, the following procedures are considered alternative options for inducing seizure: i) using the older method of sine-wave ECT, ii) promoting hyperventilation in patients [3], and iii) using anesthetic agents such as ketamine with ECT [3]. However, these are not standard methods as sine-wave ECT induces more severe side effects than pulse-wave ECT and not all anesthesiologists are fully trained in the latter two procedures.

Recently randomized control trials focusing on pulse width have been conducted [4, 5]. Sackeim et al. [4] reported that the ultrabrief pulse method, in which pulse width is less than 0.5 millisecond (ms), induces more therapeutic effects and fewer side effects and requires less electrical charge to induce seizure compared to conventional brief pulse (1.5 ms).

It could be predicted then that the ultrabrief pulse would be more effective in inducing seizure in patients with high thresholds. Contrary to this, we report a case of schizophrenia in which m-ECT with 1.0 and 1.5 ms width pulse (referred to as ‘long’ brief pulses as 0.5 ms width pulse is the default in Japan) succeeded in inducing seizure, whereas ultrabrief pulse failed. We present this case in detail and discuss the possible underlying mechanisms.

Written informed consent was obtained from the patient and his wife (legal guardian). All personal information has been anonymized.

CASE REPORT

The patient was a 35-year-old, schizophrenic, Japanese male. His history of illness started at the age of 23 years with symptoms of auditory hallucinations, persecutory delusions and psychomotor excitement. Subsequently these symptoms relapsed every one to three years. He was discharged from hospital three years ago and was being followed as an outpatient. One month ago, he complained to his doctor that he was ‘being inspected by strangers’. The atypical antipsychotic (blonanserine) and the mood stabilizer (valproate) were added to his medication but these produced the persecutory delusion that the new therapy was part of an experiment instigated by his doctor. He became

aggressive with verbal threats and was admitted to our hospital due to a lack of available beds in his regular treating hospital.

On admission, he was psychotic and extremely agitated and needed to be restrained. He initially refused treatment but eventually agreed to his old treatment regime excluding blonanserine and valproate. His medical history revealed that medication was of little effect for his relapsed symptoms while m-ECT was effective, although sine-wave ECT was necessary due to his high threshold.

The presence of brain disease such as tumours was excluded after review of computed tomography (CT) scan images. ECT treatment was started three days post admission. For the ECT interventions, we used a Somatic Thymatron ECT device, placing electrodes in a bitemporal configuration and administering propofol at 1.0 mg/kg as an anesthetic induction and succinylcholin at 1.0 mg/kg as a muscle relaxant.

Figure 1 shows the clinical course of this patient. In trials 1 to 3, we used ‘LOW 0.5’ setting, in which the pulse width is fixed at 0.5 ms, but this failed to induce seizure at the maximum dose of electrical charge (504 microulomb). We then changed the Thymatron setting from ‘LOW 0.5’ to ‘LOW 0.25’, with pulse width fixed at 0.25 ms for trial 4. Trial 4 was performed immediately after trial 3. Contrary to expectations, this did not induce seizure. In trial 5, a setting of ‘LOW 0.5’ succeeded in inducing nine second seizure, recognized by EEG and EMG charts. This seizure, however, was deemed insufficient due to its short duration. We then changed pulse width settings to 1.0 ms and administered trial 6. This setting successfully induced seizure with the desirable waveform and of sufficient duration (Figure 2).

For the remainder of the treatment we administered ECT, decreasing the electrical charge to avoid side effects. At the 1.0 ms pulse width, we achieved desirable seizures with 60 percent of the maximal charge. At the 1.5 ms pulse width, we succeeded in inducing seizure at 40 percent of the maximal charge (Figure 3).

We stopped ECT treatment after 11 trials as his psychiatric condition had improved considerably from the day of admission. He was then transferred to a chronic ward and prepared for discharge.

DISCUSSION

The patient in our case was drug-resistant and in the psychotic episode with abrupt onset. Also, we knew that he had had good responses to ECT treatments. Hence, therapeutic choice of m-ECT was thought to be in this case, proper for this patient.

For this patient, all trials at 0.25 ms width pulse failed to induce seizures while 0.5 ms width pulse was successful only once (in trial 5). It is likely that falling serum valproate concentrations enabled seizure induction in trial 5 whereas the same pulse width failed to induce convulsions in the earlier trials (1 through 3). The 1.0 ms width pulse succeeded in inducing therapeutic seizure with desirable waveform, while the

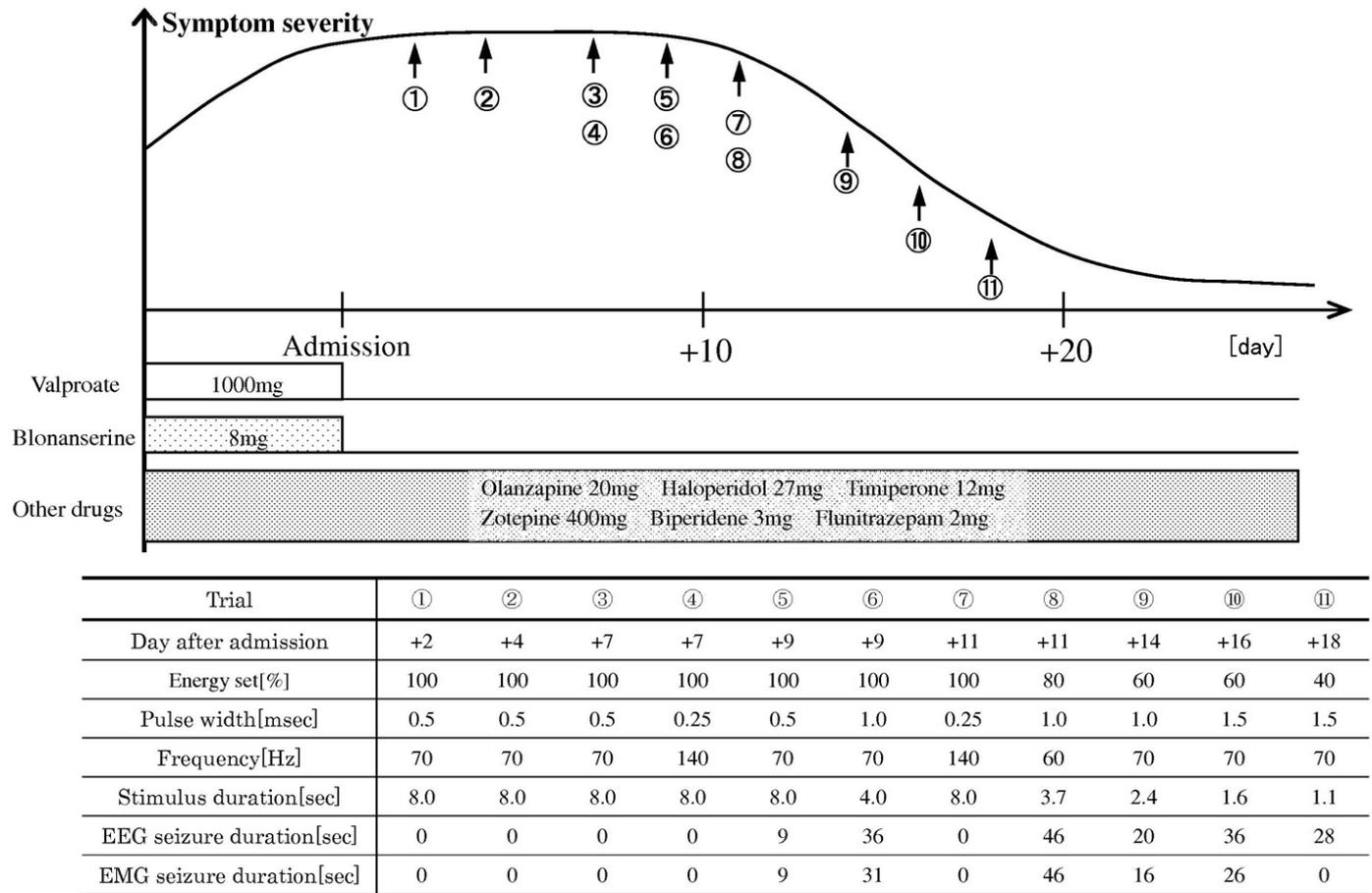


Figure 1: Clinical course.

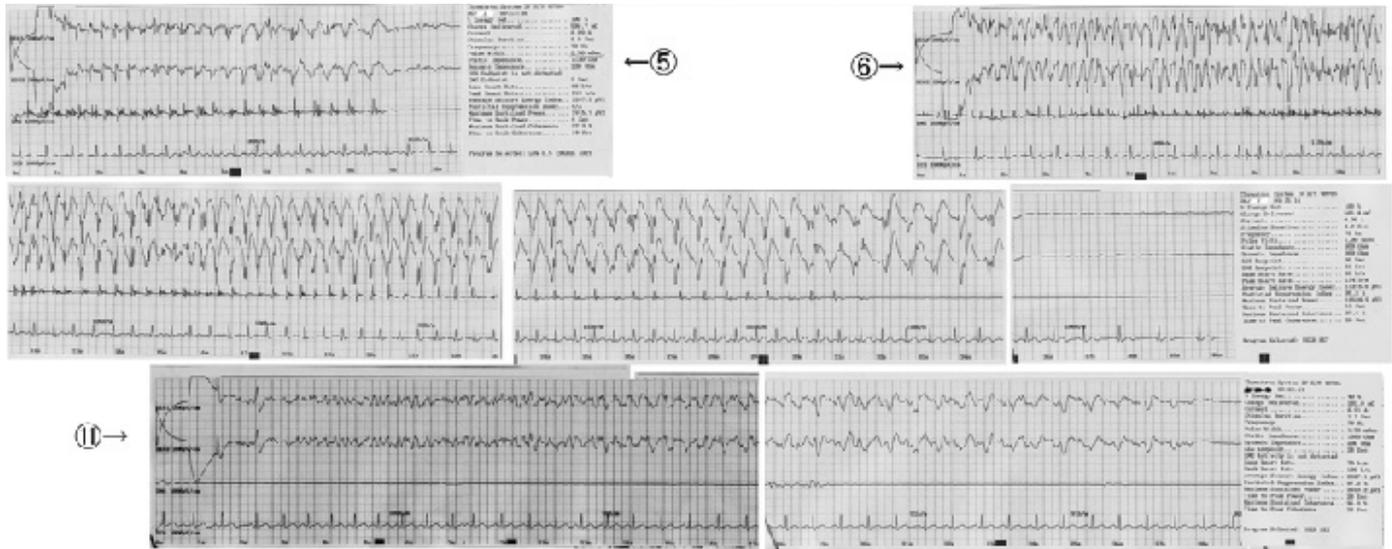


Figure 2: EEG and EMG charts of the 5th, 6th and 11th trials.

1.5 ms width pulse trials induced seizure of unknown clinical effect.

In summary, long brief pulse was more effective for inducing seizure than ultrabrief pulse for this patient. Taken together with recent RCT studies, this case

suggests that seizure threshold depends on pulse width. However, results are contradictory. In the RCT studies, ultrabrief pulse was more effective than long brief pulse for inducing seizures but, in this case, the reverse was true.

STRENGTH-DURATION PROPERTIES OF CENTRAL AXONS

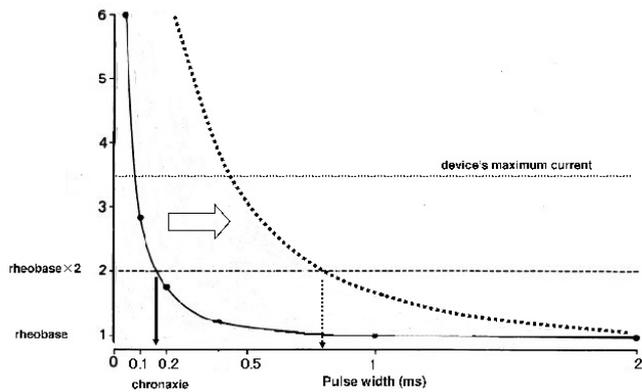


Figure 3: Strength duration curve. Strength duration curve is a graphic representation of the relationship between the minimal intensity of an electric pulse for the firing a neuron and the pulse width. As the pulse width is longer, the intensity is decreasing and closer to a certain value. The value is referred to as rheobase. Chronaxie is defined as a specific pulse width when the intensity is double of rheobase on the graph. It is known that the pulse train with chronaxie width stimulates a neuron most effectively. If the curve is right-shifted (dotted line), the chronaxie necessarily become prolonged. (This graph is modified from West et al. [7]).

Recent RCT studies of ultrabrief pulses are based on the electrophysiological fact that the chronaxie (the most effective pulse width in firing neurons) of neurons in the mammalian central nervous system lies within 0.1–0.3 ms [6]. However, West et al reported that the strength-duration curve of one-thirds of neurons is right-shifted, even in normal subjects, so that their chronaxie is prolonged [7]. We speculate that in our patient the strength-duration curve involved in ECT-induced seizures might be right-shifted resulting in prolonged chronaxie through to about 1.0 ms. Figure 3 shows a possible mechanistic explanation for this apparent contradiction. Moreover, this view accords well with the fact that there is little clinical difference between a 0.25 ms and 0.5 ms width pulse [8]. If the strength-duration curve is not right-shifted (in an individual, or where sample size is such that this can be assumed), then the difference in electrophysiological response produced by a pulse width of a 0.25 ms compared to 0.5 ms is negligible relative to the difference in response between 0.3 ms compared to 1.5 ms.

Although our hypothesis is likely to bridge clinical usage of ECT and relevant fundamental research, it is first necessary to confirm whether our observations are limited to this case or are applicable to a wider group of patients with careful ECT treatment.

CONCLUSION

This case and recent studies suggest that seizure threshold in pulse-wave ECT depends on the pulse width. In cases where default conditions fail to induce

seizures, consideration should be given to the use of long brief pulse as a well as ultrabrief pulse.

Author Contributions

Hiroaki Inomata – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Hirohiko Harima – Acquisition of data, Revising it critically for important intellectual content, Final approval of the version to be published

Masanari Itokawa - Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Guarantor

The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

Copyright

© Hiroaki Inomata et al. 2012; This article is distributed under the terms of Creative Commons attribution 3.0 License which permits unrestricted use, distribution and reproduction in any means provided the original authors and original publisher are properly credited. (Please see www.ijcasereportsandimages.com/copyright-policy.php for more information.)

REFERENCES

1. American Psychiatric Association. The Practice of Electroconvulsive Therapy: Recommendations for Treatment, Training, and Privileging (A Task Force Report) 2001:2nd ed. American Psychiatric Publishing.
2. Abrams R. Electroconvulsive Therapy 2002:4th ed. Oxford University Press.
3. Loo C, Simpson B, MacPherson R. Augmentation strategies in electroconvulsive therapy. J ECT 2010 Sep;26(3):202-7.
4. Sackeim HA, Prudic J, Nobler MS, et al. Effects of pulse width and electrode placement on the efficacy and cognitive effects of electroconvulsive therapy. Brain Stimulation 2008;1:71-83.
5. Loo C, Sainsburt K, Sheehan P, Lyndon B. A comparison of RUL ultrabrief pulse (0.3ms) ECT and standard RUL ECT. Int J Neuropsychopharmacol 2008 Nov;11(7):883-90.
6. Peterchev AV, Rosa MA, Deng ZD, Prudic J, Lisanby SH. ECT Stimulus Parameters: Rethinking dosage. J ECT 2010;26:159-74.
7. West DC, Wolstencroft JH. Strength-duration characteristics of myelinated and non-myelinated bulbospinal axon in the cat spinal cord. J Physiol 1983 Apr;337:37-50.

8. Niemantsverdriet L, Birkenhaqer TK, van der Broek WW. The efficacy of ultrabrief-pulse (0.25 ms) versus brief-pulse (0.5 ms) bilateral electroconvulsive therapy in major depression. *J ECT* 2011;27:55-8.