Overview

Monitoring the Seizure Efficacy during Electroconvulsive Therapy

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Background: For electroconvulsive therapy (ECT) to work effectively, the induced seizure should be adequate. The key measures for seizure adequacy are observed muscle movement and the electroencephalographic (EEG) finding during the seizure. Methods: The authors reviewed all available literature on the topic and added personal experiences in writing this overview article. Results: Even though most modern ECT devices are equipped with electroencephalography (EEG), electrocardiography (ECG), electromyography (EMG) or optical motion sensor (OMS), the observed seizure muscle movement is the simplest and a most reliable method for monitoring the seizure. EMG and OMS are high-tech methods of monitoring muscle movement, but the reliability can be compromised due to artifacts. EEG is routinely used for monitoring a seizure because only EEG can reflect the actual physiological response in the brain and when muscle movement is obliterated by muscle relaxants during ECT, only EEG can accurately confirm the occurrence of a seizure. Conclusion: Modern ECT monitoring techniques can provide clinically useful information, but the clinician should also know the possible interference factors to be sure that the induced seizure is adequate to ensure the ECT efficacy. Therefore, combining the EEG finding with the observed muscle movement with cuff technique is the best way to monitor the efficacy of seizure during ECT.

Key words: ECT, EEG, EMG, cuff technique

Introduction

Electroconvulsive therapy (ECT) is an effective treatment for severe mental illnesses. In patients with catatonic schizophrenia and major depressive disorder with suicidal thought, ECT is the treatment of choice because of its effectiveness and quicker action [1]. ECT works through the electrophysiological response of the brain by inducing a grand mal seizure through electric stimulation [1,2]. Although ECT has been avail-

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able for more than 70 years and is a safe and simple treatment, psychiatrists still do not use ECT enough. The main reasons are their bias and misunderstanding of “electric shock to the brain,” and possible complications of arrhythmia, cognitive impairment, temporary retrograde and anterograde amnesia, and bone fractures [3-6]. Lay people also shy away from “electric shock” for fear of brain damage caused by a direct shock to the brain, even though the fears lack scientific evidence [7,8]. After the introduction of psychotropic drugs in the 1950s, psychopharmacologic treatments have been believed to totally replace ECT. The speculation was proven to be wrong and ECT still has its place for treating severe mental disorders. Due to the lack of proper understanding, some psychiatrists are caught in the conflict between expecting ECT effectiveness and being fearful of the damage to the brain; thus, many suitable patients miss beneficial opportunities from ECT [6].

To make ECT to be effective and to have minimized the side effects, psychiatrists should be able to evaluate and determine what an effective seizure is. EKG, EEG, EMG, OSM and pulse oximetry are important methods of monitoring the physiologic responses during ECT. Psychiatrists should familiarize themselves with these measurements to ensure the safety of ECT [9]. When a seizure is not induced by electric stimulation or prolonged, the psychiatrist should know how to manage the situation to minimize adverse effects.

The purpose of this paper was to review the methods to monitor the efficacy of ECT-induced seizures with an emphasis on observing muscle movement.

Monitoring the ECT-induced seizure

An ECT-induced generalized seizure can be monitored by observed muscle movement and the EEG tracing.

A. EEG-monitoring during ECT

In 1990, The Association for Convulsive Therapy (ACT), which is a task force committee of the American Psychiatric Association (APA), included EEG as a necessary item to monitor the seizure during ECT for the following reasons [9-13]:

1. The EEG tracing accurately reflects the electrophysiologic response in the brain during a seizure.

2. Usually, seizure duration recorded by EEG is about 10 to 30 seconds longer than that of the observed muscle movement with the naked eye. Seizure duration is the time lapsed between the end of electric stimulation and the cessation of the seizure. The seizure duration should be greater than 15 seconds to make ECT treatment effective. To accurately measure seizure duration, the psychiatrist needs to wait until seizure activity in the brain has completely stopped. This measurement can only be done by EEG-monitoring. In fact, muscle movements in different parts of the body during ECT do not stop at the same time. This variance can cause some confusion in measuring seizure duration. In 1990, APA suggested that psychiatrist should apply the same criteria to standardize the determination of the seizure endpoint.

3. Sometimes the ECT-induced physiologic response can only be shown by the EEG tracing without obvious muscle movement. But the
importance of EEG can not be emphasized too strongly.

4. In 1990 APA also indicated that only through EEG-monitoring, clinicians can tell whether the seizure in the brain lasts too long, such as in this case a prolonged seizure or status epilepticus during ECT.

Abortive seizure of short seizure of less than 15 seconds lacks the therapeutic efficacy, and prolonged seizure of 180 seconds or longer increases the possibility of post-ictal confusion, short-term memory impairment, or headache. EEG-tracing during ECT is the golden standard for modern ECT with the use of muscle relaxants. EEG can be used to monitor the physiologic response of brain from the electrical stimulant and to show whether the seizure is adequate. But, in practice, EEG tracing can be subjected to artifacts and sometimes the tracing fails due to mechanical problems such as improper placement of tracing paper, or loose EEG electrode attachment, etc.

**B. Monitoring the muscle movement during ECT**

The literature also stresses the importance of monitoring the muscle movement simultaneously for the following reasons [14-16]:

1. EEG tracing during ECT is subject to artifacts such as alternative current, electrodes, perspiration, muscle movement, eye ball movement, non-seizure muscle movements induced by direct electric stimulation, pulsation, etc. These artifacts can compromise the accuracy of EEG-recording.

2. In general, motor response appears earlier than the EEG change. Therefore, muscle movement can be for monitoring the onset of a seizure more accurately.

3. Is it therapeutic effective if there is only EEG change without motor response during ECT?

No definite answer to the question has been established. Therefore, observing motor activity still has its clinical significance.

Monitoring the muscle movement during ECT is a simple reliable way to monitor the seizure. But monitoring muscle movement during ECT is less precise than with EEG and it can be totally blocked when a large dosage of muscle relaxant is used. Several different methods of monitoring the muscle movement have been used. Combining of EEG with observing muscle movement is the best way to monitor the efficacy of seizure during ECT.

**ECT-induced motor response**

Low intensity electric stimulation can induce movement of muscle groups, such as those for extension of the neck, flexion of ankles, and clenching of the jaw. But this kind of muscle movement is not a clinical sign of seizure activity in the brain. Rather, they are motor responses induced by direct muscle stimulation, known as non-convulsive muscle contraction. Contrary to ECT-induced seizures, non-convulsive muscle contraction ceases when muscle stimulation stopped [17]. Non-convulsive muscle contraction does not indicate a therapeutic effect. The distinction is clinically important.

Immediately or few seconds after the end of electric stimulation, the tonic phase of the seizure occurs. Then 10 to 20 seconds later, tonic phase is followed by the clonic phase of the seizure, which consists of the continuous rhythmic contraction of muscles with a gradual decrease in frequency until the movement finally stops. In general, the clonic phase of seizure lasts longer than the tonic phase [17]. When stimulated by low charge electricity, the motor response of the seizure can be delayed for 10 seconds or more or the motor response can
even be too weak to be observed [17,18].

Factors influencing ECT-induced motor response

The seizure intensity can be influenced by two factors: [A] the muscle relaxant dosage, and [B] the intensity of the electrical stimulus. The muscle relaxant recommended by APA is succinylcholine. The purpose of using a muscle relaxant during ECT is to decrease the intensity of muscle contraction and prevent the fracture of bones [19]. If a muscle relaxant is not used, the risk of bone fracture is markedly increased, especially in patients with osteoporosis. The most commonly seen are T-spinal compression fractures, long bone fractures and mandibular joint dislocation [21]. The high risk patients are those with a long duration of bed rest, osteoporosis, and old age. A muscle relaxant should be given to those patients to prevent these avoidable complications [21,22].

The degree of muscle relaxation is determined by the dosage of succinylcholine. A dosage of 0.5 mg/kg is usually not enough to block the muscle movement completely and convulsive muscle movement can still be observed. A dosage of 0.75-1.0 mg/kg can block the muscle movement completely or almost completely. Occasionally a larger dosage of succinylcholine is needed especially in patients with skeletomuscular problems or with the use of a non-depolarizing muscle relaxant previously [23]. The contraindications of administering succinylcholine are a history of bradycardia, hyperkalemia, organic phosphorous poisoning; and a past history or family history of malignant hyperthermia [24,25]. The second influencing factor is the intensity of the electrical stimulus. Low intensity stimulus can only induce weak muscle contraction which is sometimes even too weak to be recognized [20,26].

Methods of monitoring ECT-induced muscle movement:

Seizure muscle response can be monitored by applying a blood pressure cuff and observing the muscle movement (cuff technique), electromyography (EMG) or optical motor sensor (OMS) [6,27,32,35].

A. Cuff technique

Due to the use of muscle relaxant succinylcholine, patient’s muscle movement is reduced, determining of the beginning and the end of the seizure may be difficult. Therefore, the cuff technique is recommended to observe muscle movement [28]. Before succinylcholine is administered, the patient is placed with a BP cuff on a distal extremity such as the wrist or ankle, and the cuff is then inflated to 10 to 20 mmHg above the systolic BP. Thus, while succinylcholine is given intravenously, the muscle relaxant is blocked and the patient’s seizure response distal to the cuff will not be modified or interrupted [6,27]. The cuff is most commonly placed on the ankle joint because this part of the body will not affect the IV drip and not used in measuring of BP (Figure 1) [6]. In case of unilateral ECT, the cuff is recommended to be placed on the ankle on the same side of the stimulating electrode. When muscle movement is observed on the same side of the stimulating electrode, a generalized seizure has surely been induced [28,29]. When a seizure occurs, the cuff should be deflated immediately to reduce the possibility of a problem caused by reduced blood circulation. The BP cuff technique should be avoided in patients with [A] serious musculoskeletal disease, such as osteoporosis; [B] severe vascular insufficiency,
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such as diabetes, [C] sickle cell anemia, or [D] other blood clotting abnormalities [6,22].

Despite the muscle relaxation with succinylcholine, patient’s seizure muscle movement can still occur in other parts of the body and extremities not affected by the application of the cuff. Because the muscle movement of different parts of body does not stop at the same time during ECT, APA in 1990 recommended that the determination of the seizure endpoint should be standardized in each institute. The team administering ECT should pay proper attention to the cessation of muscle movement to the distal extremity where the cuff has been applied or the longest muscle movement in any part of the body [6,10].

Observed muscle movement with the cuff technique is simple and reliable. The cuff technique has a nickname of “poor man’s method” because it does not require expensive EEG machine. It can also have the advantage of clearly observing the muscle movement during seizure in the part of extremity distal to the cuff even the muscle movement of other parts of the body is too weak to be observed due to a large dosage of muscle relaxant. This method can be supplementary to the EEG-tracing to confirm the efficacy of seizure.

B. Electromyographic monitoring

Electromyography (EMG) is another method of monitoring muscle movement during a seizure. EMG which records the electrophysiological activity of muscles, is a useful indicator of muscle movement. EMG is more sensitive than the cuff technique, but is more easily subject to artifact interference [6,17]. EMG is not routinely used during ECT, but earlier ECT machines were already equipped with EMG, for example, the Thymatron DGx machine by Somatics, Ins. (Lake Bluff, IL, USA) [30]. However, the amplifier used in this type of machine can distort the waveform and make it look like an EEG wave [9]. However,
most investigators believe that EMG is a clinically useful measurement [16]. Many modern ECT machines, such as the Thymatron SYSTEM II/IV series (Lake Bluff, IL, USA) are not only equipped with the ability to automatically monitor muscle activity, but can also reduce wave distortion. EMG is a welcome supplement to the monitoring method of observed muscle movement [6,31,32].

The recording electrodes used for EMG are the same for EEG. The electrodes should be placed on the skin of the distal extremity where the cuff is applied and the distance between the electrodes should be about 3 to 4 inches (Figure 1). The skin area should be cleaned with a sponge soaked in alcohol and dried before applying the electrodes. To assure good contact between the electrode and skin, abrading gel can be used [6,30-33]. Edema of extremities or peripheral neuropathy can reduce the signals of muscle activities and obliterate the recording. For proper recording, the clinician needs to place at least one electrode over a skin area with muscle tissue underneath [31,32].

Figure 2 shows EMG recording during ECT-induced seizure muscle movement. Part a is the recording of muscle activities during the clonic phase of the seizure, and Part b is that during the postictal phase. The distinctive wave form on the EMG clearly records the muscle movement on the foot [9,33]. As mentioned previously, modern advanced ECT machines can automatically determine the endpoint of muscle movement. Therefore, EMG is a reasonably useful method for determining the endpoint of a seizure. In reality, it is not unusual for EMG to not work properly due to improper attachment of electrodes or poor skin contact due to not keeping the skin dry [12,33]. The treatment team should pay attention to these pitfalls to avoid mistakes.

EMG-monitoring is more sensitive than observing muscle movement with naked eyes. The doctor administering ECT can also pay more attention to the patient’s general condition, the vital signs, and oxygen saturation, etc. to assure the patient’s safety during ECT without fixing his eyes.

**Figure 2. EMG recording during ECT**
on the muscle movement during seizure. But the method is rather cumbersome and subjects to numerous artifacts. This is, thus a welcome supplement but is less reliable, and is not routinely used.

**C. Optical motion sensor (OMS)**

The spectrum 500 series ECT machine of MECTA Company (Lake Oswego, OR, USA) is equipped with OMS which uses a photoplethysmographic sensor to detect the muscle movement automatically. This is another method of monitoring muscle movement [34]. The sensor is strapped on patient’s finger or toe of the distal extremity where the cuff has been applied to pick up muscle activity. Figure 3 shows the recording during the tonic phase [3-A], clonic phase [3-B] and postictal phase of muscle movement [3-C]. This is a useful method to determine the endpoint of muscle movement [9,34]. As shown in figure 3, OMS picks up only the muscle movement during the clonic phase [34]. Compared with EEG tracing, the tracing showing OMS muscle activity ends 11 seconds earlier than EEG, as indicated by the arrow in 3-B and 3-C. In general, seizure duration using OMS-monitoring is 10 to 20 seconds shorter than that using EEG [6,16]. Therefore, the EEG-tracing should be continued even after the cessation of observed muscle movement to get an accurate measure of the seizure duration [15,33].

Among the factors affecting the accuracy of OMS-monitoring muscle movement, the most
The commonly encountered is the pulse artifact. The solution to this problem is to increase the pressure of the cuff to minimize the pulsation [33,34].

The OMS is a high-tech monitoring method that comes with modern advanced ECT machines and has the advantage of determining the endpoint of seizure automatically. But it is still subjected to artifacts resulting from human error, external, mechanical and physiological factors. The reliability of OMS is not better than that of EMG. OMS-monitoring is also cumbersome to use in real practice. For these reasons, OMS is not widely used routinely.

Therefore, the most reliable method of determining the efficacy of seizure by monitoring muscle movement during seizure is based on the observed muscle movement with the cuff technique.

Summary

The physiologic responses of ECT include EEG, cardiovascular and muscle movement. ECT-induced seizure activity is the crucial response determining the efficacy and adverse effect of ECT. The ECT-induced seizure activity can be monitored by motor response and EEG. EEG-monitoring has already been accepted as a necessary routine method because only EEG can show the physiologic response in the brain [9-13]. Motor response can be monitored by the cuff technique, EMG or OMS [6,31,34]. The modern advanced high-tech equipment for muscle movement monitoring can be compromised by artifacts from human error and external, mechanical or physiologic interference and these should be corrected during ECT [12,17]. These advanced methods are important for monitoring seizure muscle movement, but the simplest and most reliable method is to observe muscle movement with the cuff technique.

Psychiatrists, when administering ECT, should be able to evaluate the adequacy of seizure, understand the physiological responses, and be familiarized themselves with the management of possible adverse effects. Hoped fully this review will help treating physicians have a better knowledge of monitoring and evaluating ECT-induced seizures and muscle movement, resulting in improving the quality of patients’ care.

References


當精神科醫師執行電痙攣治療時，誘導痙攣效度的判別與測量是必備的重要評量，其主要的評估方式可藉由肌肉反應及腦電波監測。雖然目前的電痙攣治療儀大都具有腦電波、心電圖、肌電圖或光學肌肉運動感應器等設備，但是「目測肌肉痙攣反應」仍是最簡單可靠的效度判別方式。監測肌肉痙攣反應可利用壓脈帶技術、肌電圖或光學肌肉運動感應器等方式來加以測量。另外，執行電痙攣治療時腦電波的監測乃屬常規測量項目，因為只有它才能反應出實際的大腦電生理變化，而且電痙攣治療誘導出的痙攣時間過長或未出現明顯的肌肉痙攣反應時，唯有靠腦電波才得以判別。無論如何，臨床上科學化的監測器確實提供許多寶貴資訊，得以讓我們思考如何提高痙攣的品質及效率，但存在許多干擾因素卻使它們的準確度受到影響，這亦是醫師在操作與判讀資料時不可忽略的。因此，合併腦電波及應用脈壓帶技術之目測肌肉痙攣反應是電痙攣治療時判別痙攣效度最好的方法。

關鍵詞：電痙攣治療，腦電波，肌電圖，脈壓帶技術

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