ELECTROCONVULSIVE THERAPY

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20th April 2009

***Abstract*—The treatment of severe brain conditions is a widely studied area in which safety and successful outcomes are being constantly discussed. Electroconvulsive therapy is an ancient method for treating with hard brain disorders and is coming a safer treatment as the years pass. This report is trying to introduce this way of human brain electrical stimulation, showing its main purpose, and the current state of the art. The last step is centered in finding an existing and settled current technical limitation for working within a security way, whilst the electrical current delivered is strong enough for stimulating the human brain and getting the set goals.**

***Index Terms*—Depression, schyzophrenia, brain damage, mania, current technical limitation, electrodes**

I. Introduction

In patients with severe depression who has not responded to other treatment, and also in the treatment of mania, schyzophrenia and other disorders, Electroconvulsive therapy (ECT) is most often used. It is also known as electroshock, and a electrical stimulus is given to the brain via electrodes placed on the temples. In some studies, ECT was shown to be the most effective treatment for severe depression, and the result in improved quality of life in both short and long term. After treatment, drug therapy can be continued, and some patients receive continuation or maintenance ECT.

Side effects and risks of brain damage were highly discussed, but The American Psychiatric Association and the Bristish National Institute for Health and Clinical Excellence have concluded that the procedure does not cause brain damage in adults. Informed consent is a standard of modern electroconvulsive therapy, and is typically only used when is believed to be pontetially life saving. Current technical limitation must be taken into account for working in the safe side.

II. What is this?

Electroconvulsive therapy (ECT) is a treatment for a small number of severe mental illnesses. It was originally developed in the 1930s and was used widely during the 1950s and 1960s for a variety of conditions [1]. Today, an estimated 1 million people worldwide receive ECT every year [2].

ECT has a higher success rate for severe depression than any other form of treatment.It is an effective form of treatment for schizophrenia accompained by catatonia, extreme depression, mania, or other effective components, as mentioned above [3].

It is particularly useful for people who suffer from psychotic depressions or intractable mania, people who cannot take antidepressants due to problems of health or lack of response and pregnant women who suffer from depression or mania.

therapy/ect1.jpg

Fig. 1. Electroconvulsive therapy

therapy/unilateralplacement.jpg

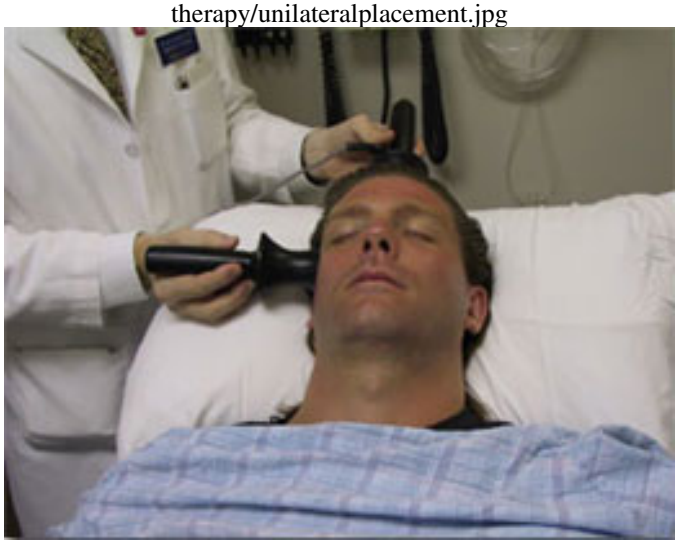

Fig. 2. Right Unilateral Placement

ECT involves placing an electrical pulse to the patient's head to cause a carefully controlled fit or seizure. Brief electrical stimulus is given to the brain via electrodes placed on the temples Fig. 1. The electrical charge lasts between $1-4$ seconds and causes an epileptic-like seizure. During ECT, patients receive a series of electrical currents to the brain that induce a 30 to 60 second generalized seizure. Patients are under general anesthesia, that may contribute to the short-

therapy/bilateralplacement.jpg

Fig. 3. Bilateral Placement

term memory loss patients experience after ECT. Patients are unaware of the seizure as the treatment is performed under full general anaesthetic, and a muscle relaxant is also given to reduce the shaking movements and prevent injury.

It is usually given 2 or 3 times a week, requiring each patient as few as 3 or 4 treatments or as many as 12 to 15.

A. How does it work?

There are numerous theories about how ECT works. In [4], three main theories are mentioned:

1) Neurotransmitter theory: ECT works like anti-depressant medication, changing the way brain receptors receive important mood-related chemicals.

2) Anti-convulsant theory: ECT-induced seizures teach the brain to resist seizures. This effort to inhibit seizures dampens abnormally active brain circuits, stabilising mood.

3) Neuroendocrine theory: The seizure causes the hypothalamus to release chemicals that cause changes throughout the body. The seizure may release a neuropeptide that regulates mood.

The precise way in which ECT works remain unknown by now. An electrode is placed above the temple of the nondominant side of the brain, and a second in the middle of the forehead (this is called unilateral ECT), view Fig. 2; or one electrode is placed above each temple (this is called bilateral ECT), as shown in Fig. 3. These are the two types of electrode placements used for the delivery of ECT. Differences between these two techniques include the area of the brain stimulated, timing of response and potential side effects.

Those receiving the right unilateral treatments may respond somewhat more slowly than those who receive bilateral treatments. Right unilateral treatment is typically associated with less memory side effects. Patients who do not respond to rgiht unilateral treatments may require a switch to bilateral placement, that is indicated for severe mental illnesses [5].

Several studies concluded that patients who received unilateral ECT performed better on attention/memory test than those who received bilateral ECT [3].

Because as many as 20 to 50 percent of the people who respond well to a course of ECT relapse within 6 months, a maintenance treatment of antidepressants, lithium or ECT at monthly or 6 weeks intervals might be advisable.

B. Common side effects and risks

It was believed to be a dangerous treatment in the ancient days, where it was not a accurated and well known method. Nowadays, it could be consider a safe, painless method.

ECT dangerous could supposed the same as minor surgery under general anaesthetic, with a death rate of approximately 1 in $10,000$.

As most of surgeries, there are some side effects to be accounted for. In summary, it had been mainly found the following controversies about ECT: poor standards, limited benefits, memory loss, psychological adverse affects and death caused by it. It may sound hard, dangerous and might make people to be afraid, but these are the worst side effects even consider and the probability of occurrence is really low.

The common side effects caused by ECT, and found in the most of patients were as follow:

1) Patchy but persistent memory loss just before and during ECT treatment, with no good evidence of long-term memory problems.

2) Confusion on walking up from the anaesthetic.

3) The ability to learn new information is impaired for several weeks after ECT treatment, but does return to normal over time.

4) Some people suffer from headaches and muscle aches straight after treatment.

ECT doesn't cause lasting brain damage, due to the amount of electricity applied to the scalp and the lesser amount that reaches the brain is too small to cause it. Despite this fact, a doctor cannot just decide to give a patient ECT, and written consent or permission to treatment must be signed by the patient.

III. Current state of the art

Electroconvulsive therapy standards and practice vary remarkably, not only between different countries but also within them and even within individual centres. Despite the activities of the Royal College of Psychiatrists, including publication of revised guidelines in 1995 in The ECT Handbook, only a little progress was found in a follow-up audit: just one-third of ECT clinics visited were considered to meet College standards and only one-third had suitable policies to assist trainee doctors in ECT (Duffett & Lelliott, 1998). During $2000 - 2001$ the Mental Health Act Commission surveyed 230 ECT facilities in England and Wales and reported that there were substantial departures from best policy, practice or training in 20% of centres (Mental Health Act Commission,2001) [6].

European practice is equally variable (Philpot et al, 2002). ECT is available only in specialist centres in Belgium and Germany, and limited by the availability of anaesthetic services in Latvia, Poland and Romania. ECT is prohibited in some cantons in Switzerland and, since 1994, can no longer be given in Slovenia. In Italy, where Cerletti and Bini first introduced

ECT, it is effectively almost abolished, more for political than scientific reasons. Approximately 6% of patients admitted to one Japanese university hospital between 1975 and 1997 were treated with ECT but how this compares with the rest of Japan is not known (Ishimoto et al, 2000). Data on national use of ECT in developing countries are not readily available. Anecdotally, ECT seems to be commonly used in parts of India, and in some African countries practice is limited by anaesthetic resources, such that unmodified ECT is used in Nigeria (Ikeji et.al., 1999) [6].

The exact reasons for such clinical variability in ECT use in the UK and abroad are unclear. Contributing factors undoubtedly include genuine public and professional concerns about the nature of the treatment, negative and stigmatising perceptions of ECT, lack of consensus on use, resource limitations plus a certain amount of complacency and neglect on the part of psychiatrists themselves.

A. Research in ECT

The vast majority of the identified research articles emanated from North America and Europe; 47% originated from the USA, 14% from the UK and nearly 9% from Israel. Single articles were identified from Germany, Italy, Spain, Austria, Sweden, South Korea and Thailand. No articles were identified in the two specialist schizophrenia journals, although ECT has a recognised role in this condition (Fink & Sackeim,1996) [6]

Thus, it seems that ECT-related research is being relatively well attended to. In addition, the advent of other new somatic therapies, such as repetitive transcranial magnetic stimulation and vagus nerve stimulation, is increasing interest again in ECT. It would be great if this interest will soon transfer into clinical practice [6].

B. The Future of the ECT

The current UK trend of declining ECT use could result from the introduction of newer antidepressants (particularly the SSRIs in the late 1980s), improved community care, earlier detection of mental illness and better appreciation of the indications for ECT. Assuming that some patients are not being denied an appropriate treatment, this reduction is broadly to be welcomed; however, it also has implications for standards of practice. Reduced use could be leading to diminished clinical interest, poor working knowledge and reduced effectiveness, further compounding the already negative public perception of ECT. The wide variations in use could also affect training. It has already been noted that some psychiatry trainees might never have the opportunity to obtain experience in ECT (Salzman, 1998) [6]

Because ECT continues to have an established and important role in the management of treatment-resistant depression and life-threatening conditions, it clearly still needs to be readily available. One possible way to overcome problems of erratic practice and haphazard training is to institute a policy of monitoring and accrediting ECT clinics as satisfying Royal College of Psychiatrists' or other internationally agreed guidelines for best practice and safety [6].

IV. Technical limitation

It was difficult to find a really stablished and assumed technical limit for the current delivered to the human brain by ECT.

Electric shock is also called electro-convulsive "therapy" or treatment (ECT), electroshock therapy or electric shock treatment (EST), electrostimulation, and electrolytic therapy (ELT). All are euphemistic terms for the same process: sending a searing blast of electricity through the brain in order to alter behavior.

In ECT, 180 to 460 volts of electricity are fired through the brain, for a tenth of a second to six seconds, either from temple to temple (bilateral ECT) or from the front to the back of one side of the head (unilateral ECT) [7] . The result is a severe convulsion, or seizure, of long duration - i.e., a grand mal convulsion, as in an epileptic fit. The usual course of treatment involves 10 to 12 shocks over a period of weeks.

What makes ECT so damaging? Bruce Wiseman [7] emphasizes that the procedure always creates grand mal seizures: Electroshock treatments send several hundredvolts of electricity through the brain. The brain then becomes starved for oxygen and pulls more blood into the brain. This causes blood vessels to break, damage to the brain, and eventual brain shrinkage. As a result of the lack of oxygen and the destruction of the nerves in the brain, the person has a seizure.

Brief-pulse devices deliver a constant current, so the voltage varies directly with the dynamic impedance of the patient. Because extremely high impedances would draw correspondingly high voltages to maintain the same current across the electrodes, thus markedly increasing the energy generated, brief-pulse devices also limit the maximum voltage that can be applied to about 500 volts [8] (the point is moot, however, because in clinical practice a patient with 500 ohms' dynamic impedance is virtually never encountered).

All energy in the ECT stimulus is eventually converted into heat, and the amount of energy is described in the same units used of heat. Risk from electricity comes from temperatures increases that correspond to the rate of heat liberation.

There are three types of ECT stimulus generators ("ECT machines"): constant current, constant voltage, and fixed charge. All commercially available modern stimulus generators supply a constant (and therefore limited) current. This means that voltage increases with impedance because current remains fixed. This is generally safer than constant voltage because of the possibility of a short circuit between the electrodes (as from sweat, gel ,water, or if electrodes are too near each other). With constant current, a short circuit produces impedance near zero and thereby a voltage near zero. No burn can occur because the rate of energy release is low, as it equals impedance times current squared. In this circunmstance impedance is low and current does not change, so their multiplication product is low.

Skin burns can occur with constant current ECT. This can happen in the circumstance that is the opposite of a short circuit: extremely high impedance between the two electrodes. In practice, this occurs only when there is poor contact between the electrode and the skin or between the

electrode and the ECT instrument itself. Poor contact means high impedance. There is a one-to-one relantionship between high impedance and high heat release,so keeping impedance down is essential.

Moreover, the energy in constant current ECT stimuli is far too small to produce a burn anywhere but where the electrode meets the skin. Even if all the electrical current were to enter the brain and liberate 100 joules in its path, brain tissue temperature would increase by less than $0.1\,^{\circ}\mathrm{C}$ (Swartz, 1989) [6]. However, only about 1% of the electrical current crosses the bony skull into the brain because skull impedance is about 100 times higher than skin impedance (Weaver et.al., 1976).

The question is how high would an ECT stimulus have to be to cause injury? Electrical injury derives from the heat of electrical energy dissipation. A very conservative safe upper limit for ECT stimulus energy regarding the most vulnerable site, the skin, is settled to 610 joules [9]. Before brain tissue would be injured by electrical heating, the skull would become painfully hot , and in ECT practice skull heating does not occur, of course. Before the ECT stimulus dose is applied, the electrical connection is examined, resulting in an impedance whose value must be in an ordinary range of 100 to 320 ohms. A higher dynamic impedance indicates poor connection to the patient.

Equal result is obtained in the study made by R. Railton et.al. [10], where ten patients who received constant voltage therapy the minimum resistance was 200Ω and the largest resistance was 320Ω, a limit impedance that can be assumed as a upper technical limit.

It have to be taken into account that the time must be limited as well to avoid applying excessive stimulus energy to the patient [11]. Some prodecures mentioned above indicated time ranges settled in the ECT treatment.

V. Conclusion

Through the analized information got from several studies, ECT could be consider a safe and effective treatment of severe depression, and provides a welcome relief from the suffering.

As the DHSS (Department of Health and Social Security, 1982) recommends, constant current instruments for delivering the electrical energy required are better than other one's, due to it is a safer way [10].

In the same way that in the most of brain stimulation methods, it can be concluded that stimulation cause in brain seizures reduction and improvement of menthal illnesses. Despite this fact, the same issue that appears in our previous researches is coming up again: there is lack of information about an stablished current technical limit that can be deivered to the human brain. It is a serious matter that should be totally controlled and clearly reported.

References

[1] L. The Royal College of Psychiatrists, "Electroconvulsive therapy (ect)," tech. rep., http://www.rcpsych.ac.uk/mentalhealthinfoforall/treatments/ect.aspx.

[2] t. f. e. Wikipedia, "Electroconvulsive therapy," tech. rep., http://en.wikipedia.org/wiki/Electroconvulsivetherapy.

[3] D. Jaffe, "All about ect," tech. rep., National Alliance for the Mentally III.

[4] "Electroconvulsive therapy (ect)," tech. rep., Menthal Health Foundation, 2000.

[5] D. F. Maixner, "Electroconvulsive therapy program," tech. rep., Psychiatry, University of Michigan.

[6] D. McLoughlin, "Electroconvulsive therapy - state of the art," tech. rep., Institute of Psychiatry, London, 2003.

[7] "Ect & brain damage: Psychiatry's legacy," tech. rep., Say No To Psychiatry. Foundation for Truth in Reality. Gene Zimmer, 1999.

[8] R. Abrams, "Electroconvulsive therapy," tech. rep., 2002.

[9] C. M. Swartz, "Scientific and experimental bases of electroconvulsive therapy," tech. rep., Cambridge University Press.

[10] A. R.Railton, J.Fisher and J.M.Shrigmankar, "Comparison of electrical measurements on constant voltage and constant current ect machines," tech. rep., British Journal of Psychiatry, 1987.

[11] J. Lelon A. Weaver and R. W. Williams, "Stimulus parameters and electroconvulsive therapy," tech. rep., Departments of Psychiatry and Electrical Engineering. University of Vermont.