

EEG Abnormalities in Clinically Diagnosed Brain Death Organ Donors in Iranian Tissue Bank

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Abstract- Brain death is defined as the permanent, irreversible and concurrent loss of all brain and brain stem functions. Brain death diagnosis is based on clinical criteria and it is not routine to use paraclinical studies. In some countries, electroencephalogram (EEG) is performed in all patients for the determination of brain death while there is some skepticism in relying on EEG as a confirmatory test for brain death diagnosis. In this study, we assessed the validity of EEG and its abnormalities in brain death diagnosis. In this retrospective study, we used 153 EEGs from medical records of 89 brain death patients in organ procurement unit of the Iranian Tissue Bank admitted during 2002-2008. We extracted and analyzed information including EEGs, which were examined by a neurologist for waves, artifacts and EEG abnormalities. The mean age of the patients was 27.2 ± 12.7 years. The most common cause of brain death was multiple traumas due to accident (65%). The most prevalent artifact was electrical transformer. 125 EEGs (82%) were isoelectric (ECS) and seven EEGs (5%) were depictive of some cerebral activity which upon repeat EEGs, they showed ECS patterns too. There was no relationship between cause of brain death and cerebral activity in EEGs of the patients. In this study, we could confirm ECS patterns in all brain death patients whose status had earlier been diagnosed clinically. Considering the results of this study, it seems sensible to perform EEG as a final confirmatory test as an assurance to the patients' families.

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Introduction

Brain death is defined as a permanent, irreversible and simultaneous loss of all brain and brain stem functions. In clinical terms, brain death is equal to the termination of human life; therefore, its diagnosis is very important and controversial in different countries.

To assess the accuracy of clinical evaluation in the determination of brain death, inclusion and exclusion criteria are established. Inclusion criteria are the ones that should all exist and absence of even one criterion renders diagnosis of cerebral death unreliable. These criteria include the clinical state and confirmatory tests. Exclusion criteria are the criteria by which we cannot definitely make the diagnosis of brain death (1). Brain

death is characterized by complete apnea, absence of brainstem reflexes, and cerebral unresponsiveness (2-4). Although these criteria define clinical brain death, but it is far more sensible to use paraclinical methods and confirmatory tests for brain death diagnosis.

In some countries like the United States, brain death diagnosis is based on clinical criteria and confirmatory tests including paraclinical studies are recommendable than mandatory (5). Such standards vary in other countries; for example in France and Italy, confirmatory tests are required by law, while in the United Kingdom, confirmatory tests are regarded as unnecessary (5,6). Apnea test, Electroencephalography (EEG), Somatosensory and Brainstem Auditory Evoked Potentials, Selective 4-vessel angiography, Isotope

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angiography, Transcranial Doppler sonography, Xenon CT scan, cerebral blood flow and Magnetic Resonance Imaging studies are some of the most important confirmatory tests in brain death diagnosis (7-9). In Iran, EEG is to be done as a confirmatory test (1). The Organ Procurement Unit in the Iranian Tissue Bank, should confirm the diagnosis of brain death after at least two isoelectric EEGs (EEGs taken with a minimum of a six-hour interval and after 20 minutes of monitoring) (1).

In the course of revolutions of the brain death criteria, especially in the past, there was much insistence on applying EEG in order to diagnose brain death and Electro Cerebral Silence (ECS) patterns were considered essential to confirm brain death (1). Nowadays, brain death confirmation with ECS patterns on EEGs is seen in many countries but over time, the accuracy of EEG in diagnosing brain death has been limited by some factors: 1) ECS patterns are not always equal to brain death; 2) they do not provide any information about brain stem functions; 3) there is always the risk of mistaking artifacts for residual cortical activities (especially in ICUs); 4) it takes a long time to perform (6,7). It seems that in some brain death patients other EEG patterns may be present (5,10-13). In the present study, we aimed to investigate EEG abnormalities in clinically diagnosed brain death patients with positive apnea test to obtain the frequency of all patterns especially ECS in their encephalograms.

Materials and Methods

In this cross-sectional retrospective study, the EEGs (n=153) collected by EEG device (Medelec Profile, Oxford, England) from the existing medical records of 89 brain death patient admitted in the Iranian Tissue Bank during 2002–2008 were examined by a neurologist skilled in reading and interpreting all types of waves and artifacts in EEGs. The EEG results and other demographic information, etiologies of brain deaths, etc were recorded in data sheets and were later analyzed by SPSS software.

Results

The male to female ratio (55 to 34) was 1.6. And the mean age \pm SD of the patients was 27.2 ± 12.7 yrs. The youngest and the oldest patients were 9 and 60 years old, respectively. The most common causes of brain death respectively were multiple traumas (65%) due to accidents and falls, cerebrovascular events (25%) and other causes (10%) such as brain tumors, poisoning, epilepsy, and hanging. The mean interval between coma and brain death diagnosis, when the first EEG was recorded, was 67.4 ± 62 hours. We found that 56, 30, 2, and 1 of the brain death patients had 2, 1, 3, and 4 EEGs recordings, respectively.

After interpretation of 153 EEGs, we found electro cerebral silence in 125 (82%) EEGs but 7 (5%) EEGs were indicative of electrocerebral activity without ECS patterns; and 21 (9%) EEGs were suspected of being isoelectric (in 5 (3.5%) EEGs the recorded voltage was more than $5 \mu\text{v}/\text{mm}$, in 14 (9%) no voltage had been recorded, and in 2, the EEGs were not reportable due to various artifacts). All of the 7 EEGs with electrocerebral activity were the initial EEG recordings and they later showed isoelectric (ECS) patterns.

The mean interval between the first and the second EEGs was 13.6 hours. There were no correlations between ECS patterns on EEGs and the interval between coma and brain death diagnosis, (P -value >0.05). We also found that there were no correlations between the presence of electrocerebral activity on EEGs and causes of brain death, (P -value >0.05); (Table 1).

111 (72.5%) EEGs showed signs of broken connections. There were also electrical transformer, ECG artifacts, frequency artifacts, electrode popping, referential, metallic and movement artifacts in 111, 54, 30, 26, 5, 4 and 3 EEGs, respectively. No artifacts were seen in 7 EEGs. We could not find any correlation between the type of EEG abnormalities in brain death donors and their age or sex, ($P>0.05$).

Table 1. Incidence of electrocerebral activity in different brain death causes.

		ECS	electrocerebral activity	Suspected to be isoelectric	<i>P</i> value
Brain death causes	Multiple trauma	81	5	16	0.71
	Cerebrovascular events	30	2	4	
	Other causes	14	0	1	

Discussion

In this study, we found electrocerebral activity in 7 EEGs which were the initial EEG recordings of 7 (8%) clinically diagnosed brain death patients. After repeat EEGs of these individuals, we found ECS patterns in their EEGs. It can be concluded that clinical diagnosis of brain death can be confirmed by EEGs if they are taken at least twice, with a six-hour interval and 20 minutes duration. Under these conditions, two isoelectric patterns can confirm clinical diagnosis of brain death (1).

In Grigg's *et al.* study (10), about 20% of clinically diagnosed brain death patients did not show ECS patterns, instead they displayed some electrocerebral activity in their EEGs several hours to several days after the first diagnosis (5,10,13). They concluded that the use of the EEG as a confirmatory test of brain death might be of questionable values (10). In some other sources, it is mentioned that EEGs are not required for the diagnosis of brain death and they are considered only as a supportive test (12,14). On the other hand, some authors believe that the diagnosis of brain death should be based on the entire clinical picture and results of available studies and they should not only be made by one test or clinical situation (15).

These studies have shown the technical pitfalls and limitations of EEG application in the diagnosis of brain death, which can be summarized as follows: EEGs do not provide direct information about brainstem functions; EEGs may be flat in patients with preserved brainstem functions; EEGs are unreliable in patients with hypothermic sedation or presence of toxic or metabolic factors and artifacts may conceal any electrocerebral activity (6,7). It is said that EEGs should be performed after exclusion of endocrine or metabolic coma, intoxication with CNS depressants or hypothermia which generate ECS patterns (6,12,16).

More errors are seen in reporting ECS patterns obtained with voltages greater than 2–2.5 $\mu\text{v}/\text{mm}$ (16). In this study, we did not find alpha coma, beta or low voltage theta waves while in a study carried out in 1987; they found these waves in clinically diagnosed brain death patients (10). In the 14th chapter of Current Practice of Clinical Electroencephalography, the authors declare that there is no correlation between ECS appearance and any special pathological findings and patients with ECS patterns on their EEGs have a significantly higher incidence of swollen brains, cerebral herniations or respirator brain (5). In conclusion, we found that it is better to perform EEG as a final

confirmatory test for the diagnosis of brain death and also as a measure of assurance for the patients' relatives but it is essentially important to perform EEGs in standard set-ups and to interpret them accurately by trained neurologists to minimize the chances of errors.

Although we did not find any relationship between brain death etiologies and ECS pattern appearance, it seems quite relevant to conduct a study to evaluate any relationship between brain pathologies and EEG findings in clinically diagnosed brain death patients.

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It is to be noted that some EEGs had been removed from the patients' medical files after five years of organ donation and we could not access them.

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