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뇌사의 진단과 진단을 위한 보조적 검사

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The Diagnosis and Ancillary Tests of Brain Death

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Brain death is defined as the irreversible cessation of all brain function. The diagnosis of brain death is primarily based on a careful neurological examination demonstrating unresponsiveness, absent of brain stem reflexes, and no respiratory activity. Several conditions which may mimic brain death must be excluded. In some cases investigations such as electroencephalography, angiography, transcranial doppler or evoked potentials can contribute to the diagnosis. The brief review will introduce medical technologist and clinician to the key issues in the definition and management of brain death.

Key Words: Brain death, Electroencephalography, Angiography, Transcranial doppler, Evoked potential

I. INTRODUCTION

Initial efforts to define death in this age of technological advancement included development of Harvard criteria in 1968 by an ad hoc committee on brain death at Harvard Medical School (HMS, 1968; Paul, 1994). As technological complexity and advancement in critical care continued to explode during the past several decades, the concept of death as defined by neurological criteria, that is brain death emerged and evolved as a necessary measure for determining death. Before the development of these neurological criteria, death was classically described as the cessation of circulation and respiration. However, the advent of mechanical ventilation and of methods or cardiovascular support presented new challenges for determining the end of life for patients with catastrophic cerebral injuries whose lives could be preserved by using these complex technological devices.

Although the diagnosis of brain death is a clinical one, occasional the clinician may seek guidance from a variety of ancillary tests. Perhaps the most common such test is electroencephalography, the expected finding being a "electroencerebral silence" or "isoelectric" EEG (Chatrian, 1986; Walker, 1985). As well, confirmation of brainstem death can be facilitated by observing a flat auditory brainstem response(ABR) and somatosensory(Hall *et al.*, 1985). Absence of cerebral circulation can be demonstrated by four-vessels angiography and radionuclide methods(Kuni and Rogge, 1986). More recently, absent flow signals on transcranial Doppler ultrasonography has also been suggested as a method to demonstrated the absence of cerebral circulation in brain death (Gilmore, 1994; Kirkham *et al.*, 1987). All these methods suffer from potential technical problems that require skilled

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technical support to make the techniques meaningful and reliable in the ICU environment.

In this article, we summarize the most recent evidence-based guidelines for determining brain death. Although these guidelines reflect generic, scientifically based recommendations, adaptation of certain details may vary across practice settings, clinicians, and medical technologists.

Ⅱ. MATERIALS and METHOD

We performed a literature search of studies published between 1960 and January 2003, by using MEDLINE, and manually searched bibliographies of the identified articles. Electronic search term brain death.

1. Diagnosis

1) Precedent a Condition for Clinical Determination of Brain Death

Before the criteria can be applied, ①brain tumor, trauma, and stroke may also cause complete destruction of the brain, ②irreversible cessation of circulation and respiratory functions, ③confirmation of the absence of drug intoxication or acute metabolic or endocrine derangements (renal, hepatic), ④hypothermia of less than 32℃, and ⑤no cardiogenic shock (KMA, 1998).

2) Criteria for Clinical Determination of Brain Death

An individual with irreversible cessation of all functions of the entire brain, including the brain stem, is dead if the following are true: ①absent movement of response to deep stimulation. ②Spontaneous respiration is absent. ③ The pupils are dilated. ④ Brainstem reflexes should be absent light, corneal, oculo-cephalic, vestibular-ocular, cilio-spinal, gag, and cough reflex. ⑤Spontaneous movement, decerebrate rigidity, decorticate rigidity, and seizure are also absent. ⑥Apnea test is positive. Most experts recommend an arbitrary interval of 6 hours between initial and repeat observation for clinical determination of brain death in adults. ⑦EEG is not activity during the recording.

The recommended observation period depends on the age of the patient and the laboratory tests utilized. Two months to one year-The examination and EEG separated by at least 48 hours. One year to five years- The two times examination and one time EEG separated by at least 24 hours. A repeat examination and EEG are not necessary if a concomitant radionuclide angiographic study demonstrates no visualization of cerebral arteries (KMA, 1998).

2. Ancillary Tests

1) Electroencephalography (EEG)

EEGs are performed mainly to provide supportive evidence of brain death. Although brain death is defined by clinical criteria, some situations preclude complete or definitive examination findings. EEG needs to be performed according to strict criteria for clinical as well as medical-legal determinations. In patients with brain death, no electrical activity occurs during a period of at least 30 minutes of EEG recording.

Electrocerebral inactivity (ECI), or electrocerebral silence (ECS) is defined as no cerebral activity over 2 ㎶ using two montages that uses electrode pairs at least 10 ㎝ apart with interelectrode impedance <10,000 ohms and >100 ohms.

According to guidelines of Korean Medical Association, the following are minimum technical standards for EEG recording in suspected brain death(KMA, 1998):

* A minimum of 8 scalp electrodes
* Impedances between 100 and 10,000 ohms
* Integrity of entire recording system tested by touching each electrode individually to obtain appropriately located artifact potential
* Interelectrode distances of at least 10 ㎝
* Sensitivity of at least 2 ㎶ for 30 minutes of the recording, with appropriate calibrations documented
* High-frequency filter(HFF) not set below 30 Hz and low-frequency filter(LFF) not set above 1 Hz
* Additional monitoring techniques used as necessary to eliminate or prove waveforms are artifactual
* No EEG reactivity to strong and through pain, auditory, or visual stimulatio

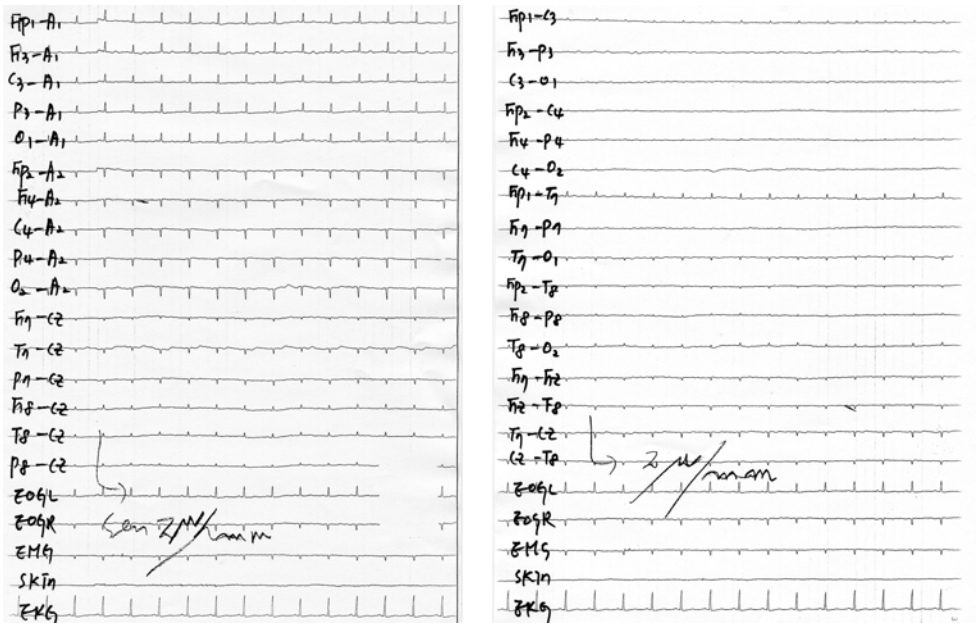

Fig. 1. This recording is from a 34-year-old man who had a traffic accident. This EEG has not contain cerebral activity, just artifact. This artifacts commonly seen in this type of recording are due to heart beat, and pulse wave (2μV/mm).

2) Transcranial Doppler Sonography

In transcranial Doppler sonography, intracranial arteries are insonated bilaterally(middle cerebral artery). Ten percent of patients may not have temporal insonation windows. Therefore, initial absence of Doppler signals cannot be interpreted as consistent with brain death. Findings consistent with brain death indicate high vascular resistance associated with greatly increased intracranial pressure and include absent diastolic or reverberating flow, systolic-only flow or retrograde diastolic flow, and small systolic peaks in early systole. Blood flow velocities may be influenced by marked changes in Pco2, hemartocrit, and cardiac output (Jalili *et al.*, 1994; Kuni and Rogge, 1986; Newell, 1995; Payen *et al.*, 1990; Petty *et al.*, 1990; Wijdicks, 1995).

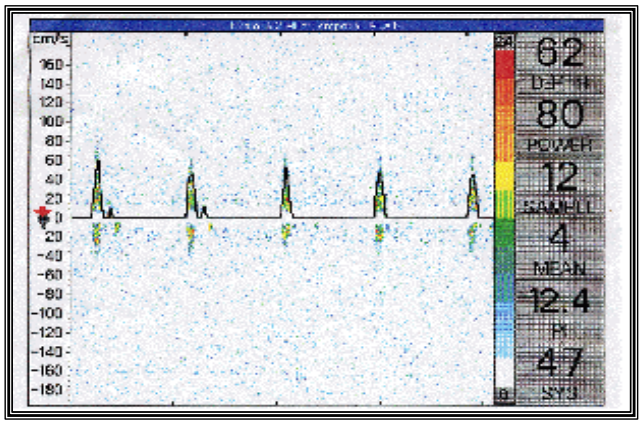

Fig. 2. Examination of the middle cerebral artery in cerebral circulatory arrest.

3) Somatosensory and Brain Stem Auditory Evoked Potentials

Testing for somatosensory evoked potentials is done at the bedside with a portable instrument that provides bilateral stimulation of median nerves. In studies, of patients with brain death, most patients had no responses to tests for somatosensory and brain stem auditory evoked potentials (Goldie *et al.*, 1981; Ying *et al.*, 1992).

4) Conventional Cerebral Angiography

Absent cerebral blood flow. A persistent absence of cerebral blood flow determined by radionuclide angiography is diagnostic of brain death. However, a conventional angiogram is seldom necessary when clinical observation and EEG are available (15 Walker, 1985).

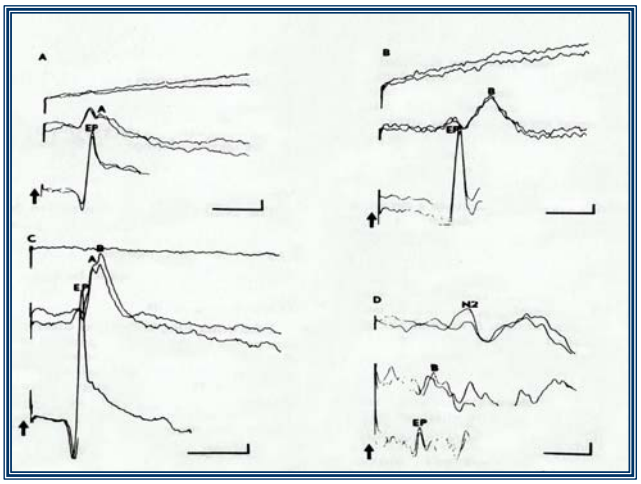

Fig. 3. SEPs from three brain death patients (A-C) and a comatose but not brain death patient (D). The three tracings for each patient represent scalp (top), neck (middle), and clavicular (bottom) recordings. The three brain death patients have no scalp SEPs. Neck and Clavicular SEPs preserved although the neck SEP in patient (A) is abnormal. The comatose patient in (D) has cervical and scalp peaks preserved although distorted and delayed (Neurology 31:248, 1981).

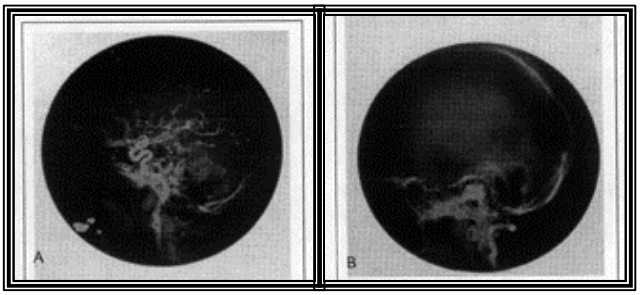

Fig. 4. In patients with brain death, intracerebral filling is absent to the level of the carotid bifurcation or circle of Willis. A is normal blood flow. B is absent cerebral circulation blood flow.

Ⅲ. RESULTS and DISCUSSION

Having a clear understanding of how brain death is determined and being able to recognize that the criteria for brain death differ from the cardiopulmonary criteria used to determine death are the first steps in eliminating the confusion and misconceptions often associated with brain death.

The EEG is run for at least 30 minutes to ensure the absence of brain waves. Absence of Doppler signals cannot be interpreted as consistent with brain death. Patients with brain death had no responses to tests for somatosensory and brain stem auditory evoked potentials. A persistent absence of cerebral blood flow determined by radionuclide angiography is diagnostic of brain death.

Ⅳ. CONCLUSIONS

A clear understanding of the criteria for brain death and an exactness of the ancillary test is the first step for diagnosis of brain death. Assisting with diagnostic testing and close observation will aid in the timely determination of brain death.

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뇌 기능의 비가역적 중단을 뇌사라 정의한다. 뇌사를 진단하기 위해 선행되어야 할 조건은 종양, 뇌졸중, 사고 등에 의한 뇌 기능의 소실된 원인이 확실하여야 하고, 자발호흡의 비가역적 중단과 약물이나 급성 대사성 장애가 없어야 하고, 저 체온 상태가 아니어야 하며, 심장 쇼크 상태가 아니어야 한다. 뇌간 반사 작용이 없어야 한다.

뇌사를 진단하기 위한 검사로는 뇌파검사와 유발전위 검사에서 뇌로부터 나오는 파형이 없어야 하고, 뇌혈류와 angiography에서 혈류의 흐름이 없어야 한다.

이 논문은 뇌사를 진단하는 신경과 의사와 뇌신경 검사를 시행하는 임상병리사에게 도움이 될 것이다.