

■ BRIEF COMMUNICATION ■

Reflex Movements in Patients with Brain Death: A Prospective Study in A Tertiary Medical Center

Reflex movements have been reported to occur in up to 75% of brain-dead patients, but this issue has not been addressed in Korea. The patients admitted to our hospital who met the criteria for brain death were enrolled between March 2003 and February 2005. The frequency and type of reflex movements in these patients were evaluated prospectively using a standardized protocol. Brain death was determined according to the guideline of Korean Medical Association. Of 26 patients who were included, five (19.2%) exhibited reflex movements such as the pronation-extension reflex, abdominal reflex, flexion reflex, the Lazarus sign, and periodic leg movements. This finding suggests that the frequency of spinal reflex movements is not rare and the awareness of these movements may prevent delays in brain-dead diagnosis and misinterpretations.

Key Words : Brain Death; Reflex, Abnormal; Organ Transplantation

Suk-Geun Han, Gyeong-Moon Kim,
Kwang Ho Lee, Chin-Sang Chung,
Ki-Young Jung

Department of Neurology, Samsung Medical Center,
Sungkyunkwan University School of Medicine, Seoul,
Korea

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Address for correspondence

Ki-Young Jung, M.D.
Department of Neurology, Samsung Medical Center,
Sungkyunkwan University School of Medicine,
50 Ilwon-dong, Gangnam-gu, Seoul 135-710, Korea
Tel : +82.2-3410-3597, Fax : +82.2-3410-0052
E-mail : kyjung@smc.samsung.co.kr

Brain death is the state of irreversible loss of brain function due to organic brain lesions. Although there are minor variations among the criteria that are used to define brain death, the essential criteria for establishing brain death include complete unresponsiveness, permanent apnea, and an absence of brainstem reflexes (1). A variety of reflex movements have been reported in patients with brain death, such as plantar responses, muscle stretch reflexes, abdominal reflexes, and finger jerks (2). Because the aforementioned reflexes are spinal reflexes, the existence of such reflex movements does not preclude the diagnosis of brain death. While the occurrence of reflex movements in brain-dead patients is not uncommon in the literature, there have been no reports of reflex movements in brain-dead patients in Korea. The purpose of the present study was to evaluate the frequency and type of reflex movements in Korean patients admitted in our hospital who fulfilled the diagnostic criteria for brain death.

Among the patients admitted to the Organ Transplantation Center at the Samsung Medical Center, Seoul, Korea, for determination of brain death and donation of organs, those who met the criteria for brain death were enrolled for the present study between March 2003 and February 2005. Brain death was determined according to the guideline of Korean Medical Association (3) in conjunction with the recommendations of the American Academy of Neurology (4) which were (i) complete clinical neurological examination including documentation of coma, the absence of brainstem reflexes, and apnea, (ii) persistence of above clinical features

for at least 6 hr (to determine irreversibility), (iii) exclusion of hypothermia, drug intoxication, and other metabolic causes of coma, and (iv) demonstration of electrocerebral inactivity by electroencephalogram performed after the second examination. The protocol (5-7) used to evoke movements consisted of (i) painful stimuli applied to the supraorbital area, sternum, and nail beds of the four limbs, (ii) neck flexion, (iii) tactile stimulation of the palmar and plantar areas, and (iv) apnea test. Any movement that occurred reproducibly was observed and recorded on the video-tape for independent examination by two neurologists.

Twenty-nine patients fulfilling the criteria of brain death were recruited during the two-year-long study period. Because the diagnosis of brain death in children is a complex clinical and ethical issue (8), three pediatric patients younger than 15 yr of age were excluded; thus the remaining 26 adult patients were examined as described above. The most common cause of brain death was either spontaneous or traumatic intracranial hemorrhage (Table 1). Fifteen patients were male (mean age, 39 ± 10 yr; range, 18-61 yr). Twenty-five of the 26 patients ultimately underwent organ harvesting. Five (19.2%) of the 26 patients exhibited reflex movements. Four patients had traumatic subdural and subarachnoid hemorrhage and one patient had a massive spontaneous intracerebral hemorrhage of the left hemisphere.

A wide range of reflex movements was observed in each patient (Table 2). Ipsilateral or contralateral pronation-extension reflex movement was observed in three patients. An

abdominal reflex movement was observed in two patients. One patient with traumatic subarachnoid hemorrhage exhibited the Lazarus sign (9), raising both arms briefly before dropping them onto the chest at painful stimulation. The triple flexion reflex movement of the leg was observed in two patients. One patient with massive intracranial hemorrhage exhibited spontaneous repetitive leg movements resembling the periodic limb movements occurring during sleep; this patient also exhibited the triple flexion reflex of the leg. This patient has been described in detail elsewhere (10). Reflex movements were evoked in all five patients in response to either painful or tactile stimuli. However, similar movements also occurred spontaneously in three patients in the absence of any apparent stimulation. Anterior neck flexion evoked pronation-extension reflexes in two patients. One patient exhibited the triple flexion reflex movement of the leg during the apnea test.

About 20% of the brain-dead patients that we examined in the present prospective study exhibited reflex movements; this is comparable to the incidence of reflex movements in brain-dead patients in other prospective studies (2, 6, 7). However, one retrospective study revealed reflex movements in 75% of brain-dead patients (11). Documentation of brain death appears to vary among medical centers (12), and the identification of a movement as a spinal reflex in brain-dead patients depends on the awareness of individual physicians as well as hospital policies (13). A prospective study of a large patient population using a standardized protocol (including definitions of reflex movements) is required to obtain an accurate description of reflex movements in brain-dead patients.

Most of patients in the present study were enrolled after admission to an organ transplantation center, to which only patients who are candidates for organ donation are referred by other hospitals. Consequently, there may have been selection bias in the present study. Moreover, only 29 patients

were diagnosed as brain dead over the course of two years; this small number of patients might reflect Koreans' views on organ transplantation, because only patients for whom family members provided consent for organ donation were transferred to the organ transplantation center. A survey of attitudes towards brain death and organ donation in Korea revealed that only half of the respondents had positive views about brain death (14).

We observed various types of reflex movement in the present study. The most common type of movement was unilateral upper limb pronation-extension reflexes, which were present in three of five patients. Although the most common reflex movements reported by a large multicenter study of brain-dead patients were undulating toe flexion response (7), we did not observe such movements in our patients. Different patient population and small number of patients in present study might account for the discrepancy from others.

There are many explanations for the reflex movements exhibited by brain-dead patients, but the mechanisms that underlie such movements remain obscure (2). One mechanism that has been proposed as underlying such reflex movements is medullary hypoxia and hypercapnea-induced activity of cervical cord neurons. The reflex movements evoked during the apnea test in one patient in the present study support this hypothesis. Others have suggested that disinhibition of movement generators of the spinal cord increase the activity of the movement generators, which provokes movement. This mechanism could explain the flexion of the lower extremities and the periodic leg movements that were observed in our patients. Alternatively, it has been hypothesized that mechanical compression/decompression of the spinal root or cervical spinal cord by neck flexion/extension can generate movement. Indeed, two of our patients exhibited reflex movements in response to neck flexion. The results of the present study suggest that there may be multiple mechanisms underlying the generation of reflex movements in brain-dead patients.

Demand for organ transplantation is increasing rapidly. Therefore, brain-dead patients are becoming an increasingly important source of organs for transplantation. If physicians are not aware of reflex movements that can occur in brain-dead patients, or if there is disagreement among physicians about the causes of such movements, determination of brain

Table 1. Causes of brain death

| Diagnosis | No. of patients |
|---------------------------------------|-----------------|
| Subarachnoid/intracerebral hemorrhage | 14 |
| Traumatic intracranial hemorrhage | 10 |
| Anoxia | 1 |
| Malignant brain tumor with bleeding | 1 |

Table 2. Characteristics of reflex movements in five brain-dead patients

| No. | Sex/Age (yr) | Cause of BD | Stimulus that evoked movement | Reflex movement |
|-----|--------------|-----------------------|---|---|
| 1 | F/61 | Traumatic SDH, SAH | Pain | Pronation-extension; raising of upper extremities |
| 2 | M/27 | Traumatic SAH, IVH | Pain; spontaneous; neck flexion | Pronation-extension; abdominal; Lazarus sign |
| 3 | M/23 | Traumatic SDH, EDH | Tactile | Pronation-extension |
| 4 | F/37 | Traumatic SAH | Pain; spontaneous; neck flexion; apnea test | Abdominal; triple flexion |
| 5 | M/50 | Hypertensive ICH, IVH | Tactile; spontaneous | Triple flexion; periodic leg movement |

BD, brain death; F, female; M, male; SAH, subarachnoid hemorrhage; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; SDH, subdural hematoma; EDH, epidural hematoma.

death might be delayed and could result in the failure of organ donation. Nevertheless, determination of brain death should be undertaken with circumspection, particularly when related to organ transplantation (15). The use of specialized medical personnel and multidisciplinary team-based approaches will ensure the highest possible accuracy with respect to determining brain death. In addition, medical training that specifically addresses brain death is required (12). The frequency of spinal reflex movements is not rare and the awareness of these movements may prevent delays in brain-dead diagnosis and misinterpretations.

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