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WHAT IS NOT BRAIN DEATH: THE VEGETATIVE STATE and MOVEMENTS IN BRAIN DEATH*

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The main objective of this meeting convened at the Pontifical Academy of Sciences is to discuss the topic of Brain Death. Although in general there is no debate within the scientific community, the concept of Brain Death has been questioned by lay people and in some cases by physicians. For this reason it seemed appropriate to begin this two-day conference discussing 'What is not Brain Death', referring to the loss of consciousness that occurs in coma and in the vegetative state, two neurological scenarios that in different medical and non medical circles are not infrequently confused or used interchangeably with brain death.

It is important to remind ourselves that the objectives defined for this Working Group on the Signs of Death at the request of Chancellor Bishop Monsignor Marcelo Sánchez Sorondo of the Pontifical Academy of Sciences following the instructions of the Holy Father Benedict XVI, is to 'study the signs of death in order to explore at a purely scientific level the application of the criterion of brain death'. Following this request, I am presenting two scientific subjects and will avoid most philosophical aspects of the discussion. The first presentation is entitled 'What is not Brain Death: The Vegetative State' and the second is 'Movements in Brain Death'.

What is not Brain Death: The Vegetative State

Consciousness

To discuss 'consciousness', we should go back as far as 1890 when William James described it as 'awareness of the self and the environment'. This implies that the state of consciousness entails being awake and aware, but not just one of them.

* The views expressed with absolute freedom in this paper should be understood as representing the views of the author and not necessarily those of the Pontifical Academy of Sciences. The views expressed in the discussion are those of the participants and not necessarily those of the Academy.

Cognitive functions allow a person to live every day with capacities that are particular to a human being. These functions were thought to be located precisely in certain parts of the brain (Figure 1, see page 415). Scientific advances over the last decade have shown that the brain interacts within itself in very sophisticated ways that make it impossible to localize the functions to one single area. It is also known that plasticity and other capacities of the nervous system permit the regeneration of certain functions lost with brain injury or disease. Following a schematic diagram for didactic purposes, it can be said that some of the functions integrated on the right hemisphere include visual and spatial orientation and music recognition among others and, on the left side (this localization works for most right as well as left handed people) there is language, calculation and, on both hemispheres, memory is localized in the temporal lobes. The frontal lobes integrate the executive function that allows a person to plan, organize and execute activities. A generalized dysfunction of these areas results in the syndromes known as dementias. Selective injuries cause syndromes manifested by the function lost (i.e. aphasia with language alterations, acalculia if calculations are impaired, and mnestic disorders when memory is affected).

These so-called 'high intellectual functions' are localized to various regions of the cerebral cortex although their function and the state of consciousness are dependent on the existence of the ascending reticular activating system (ARAS)(Figure 2, see page 415). The ARAS is a network of neuronal circuits that extends throughout the brainstem providing the neurotransmission to subcortical brain nuclei that in turn activate the cerebral cortex.

Only the dorsally located part of this reticular activating system in the brain stem receives afferent inputs from various loci with different neurotransmitters to finally exert the activity over cortical regions that maintain consciousness. These nuclei are the locus coeruleus with the neurotransmitter epinephrine, the raphe nucleus with serotonin, the basal nucleus of Meynert with acetylcholine mediated activity and the intramedian and medial thalamic nuclei, a group more recently recognized as an active station in the process of consciousness. These thalamic nuclei are the last post preceding stimulation to the different cortical regions that guarantee a state of consciousness. Their important role in consciousness has been underscored by the neuropathological findings in the Quinlan case [1]. When this system is altered as a cause of disease or trauma, a person may fall in a coma and then, according to different variables, may recover or progress to a vegetative state. Some characteristics of the latter include that it manifests as sleep-wake like cycles with complete or partial preservation of hypothalamic and brainstem autonomic functions.

By definition, when somebody loses consciousness (i.e. wakefulness and awareness) for a few seconds or minutes this clinical phenomenon is called 'loss of consciousness or syncope'. When the loss of consciousness lasts for an hour or more, then the condition is defined as coma, and the state of coma can persist for a few days or weeks following an injury to the brain. A popular scale based on the assessment of eye movements and best verbal and motor responses was designed to rapidly and reliably indicate the severity and prognosis of patients in coma (Figure 3, see page 416). In most cases, patients that remain in a coma progress to have signs of 'waking-up' after a few days or weeks. However, many of these patients fail to respond and become fully alert because they fall in the so-called 'vegetative state'. Jennett and Plum defined this neurological state in 1972 as a condition in which coma has progressed to a state of wakefulness without detectable awareness [2]. The term 'vegetative' was used many years before Jennett and Plum, referring to basic functions of the body identified even before the autonomic nervous system was described.

The Vegetative State: Diagnostic Criteria

Patients in a vegetative state show no evidence of sustained, reproducible, purposeful, or voluntary behavioral responses to visual, auditory, tactile or noxious stimuli. In addition they show no evidence of language comprehension or expression, all have bowel and bladder incontinence and variably preserved cranial nerve and spinal reflexes. These clinical criteria should be fulfilled for someone to be diagnosed as being in a vegetative state (Figure 4, see page 416).

To avoid differences in opinion and varying diagnoses, a Task Force was put together and published in 1994 in *The New England Journal of Medicine* as a two-part manuscript referring to the medical aspects of the vegetative state (Figure 5, see page 417) [3, 4]. This Task Force included the work of five medical societies and of several members from the medical, ethical and law fields to ensure the appropriate construction of the criteria. Facts that were emphasized included that patients should have irregular but cyclic sleeping and waking-like states. This implies that patients are actually not sleeping when they have their eyes closed and not awake when their eyes are open but they appear as if they were in these states. Also, they do not follow a regular pattern of closing and opening their eyes as in normal wake-sleep cycles. Patients move spontaneously and turn in their beds or move their legs around and show head turning to one side or the other and specially become active when stimulated upon being bathed or touched by caregivers. They can also look as if they are smiling or crying, although these are not consciously integrated reactions of happy or sad emotions. Patients can also make noises such as high pitched screaming, moaning or grunting spontaneously or after stimulation. Although visual fixation or tracking of moving targets (human or other) do not occur, vegetative patients have primitive orienting reflexes with eye or head turning towards certain moving or auditory stimuli. Withdrawal to visual threatening does not occur.

Although it probably added to confusion, the vegetative state was subdivided into the 'persistent vegetative state', defined as a vegetative state lasting at least one month after an acute traumatic or non traumatic injury (Figure 6, see page 417). Whenever it is possible to confirm that a person will be in a vegetative state indefinitely, the appropriate diagnosis becomes 'permanent vegetative state'. The latter implies prognosis because it defines that the patient's status is irreversible whereas when the diagnosis is 'persistent' the patient could eventually recover from the vegetative state to improved degrees of consciousness. This terminology is somewhat confusing because it is very difficult to predict with certainty that somebody will never recover to reliably give the diagnosis of a permanent vegetative state. It is easier to give this diagnosis retrospectively, as for example in the renowned case of Karen Quinlan, when one knows that the patient died without ever recovering from the vegetative state. By convention, when a patient has been vegetative for more than three months after suffering a non-traumatic injury or for a period greater than 12 months after traumatic brain injury, then the likelihood of recovering consciousness is essentially non-existent and the term permanent vegetative is appropriate.

Epidemiology, Etiology and Neuropathology

In the US there are approximately 10,000 to 25,000 adults and 4,000 to 10,000 children in a vegetative state. If we extrapolate these figures, then in the world there must be approximately 500,000 adults and approximately 200,000 children in a vegetative state, which gives an idea of the significant magnitude of this problem.

One of the most common and deadly etiologies of a vegetative state is traumatic brain injury. Non-traumatic brain injury includes toxic effects of drugs, overdose, and more commonly the hypoxic-ischemic injuries. The latter group encompasses people who suffer asphyxia, drowning, carbon monoxide poisoning and the different forms of stroke. Other etiologies include degenerative or metabolic brain disorders, such as end stage of, for example, Alzheimer's disease. Finally, severe congenital malformations of the central nervous system such as hydranencephaly can also result in a vegetative state.

The neuropathological features in the brain of affected patients at autopsy depend on the etiology of the vegetative state. In many traumatic cases 'diffuse axonal injury' is found. In this, neuronal axons suffer a sheer stress force, which damages the fiber network causing disconnection of neurons from other circuits and nuclei in the brain. This mechanism commonly operates in car o motorbike accidents in which patients do not have hemorrhages or any observable lesion by imaging of the brain, but fall in a coma or vegetative state after the accident. In non-traumatic injury, the neuropathology shows diffuse cortical laminar necrosis where the cortical layers of the brain, specially the third and fifth layers that are the most sensitive to oxygen deprivation, suffer necrosis with interruption of all neuronal activity.

Recovery from the Vegetative State

Recovery entails two different variables: consciousness and function. Recovery of consciousness may occur without any functional recovery, thus a person may remain completely paralyzed and regain consciousness. However, functional recovery cannot occur without recovery of consciousness. Approximately 1 to 14% of people that suffer traumatic coma develop a persistent vegetative state, and approximately 12% of those after non-traumatic coma will remain in a persistent vegetative state.

Figure 7 (see page 418) shows that 52% of adults and 62% of children with a diagnosis of persistent vegetative state after one month as a result of traumatic brain injury will recover consciousness at one year following trauma. The graphics on the right side show that recovery is unlikely for patients that have been one month in a vegetative state following non-traumatic brain injury. This poor prognosis affects both adults and children.

In a series of 434 adults with traumatic vegetative state reported by the American Academy of Neurology, the recovery of consciousness after 12 months was unlikely (Figure 8, see page 418) [5]. Good recovery between 6 and 12 months was seen in 0.5% of patients affected and none of the patients had good recovery beginning after 12 months. Most patients in this group recovered consciousness with moderate disability. Among 106 children with traumatic injury that survived 8 months, 54% persisted in a vegetative state, 32% had regained some consciousness and 14% were dead. At 3 months, among 169 adults with non-traumatic brain injury, 93% had died within one month or remained vegetative, 7% recovered consciousness, and only 1% recovered some function. Regarding the 45 children available in the non-traumatic series, among those surviving 6 months, 97% were in a vegetative state and 3% had regained consciousness with some degree of disability.

This series reflects that recovery after traumetic vegetative state can be expected to occur during the first 12 months, whereas in the case of non-traumatic vegetative state the limit is reduced to 3 months.

Survival

Despite significant advances in neurointensive care, the average survival of patients in vegetative state is from 2 to 5 years, and exceptionally beyond 10 years. The probability of prolonged survival is 1/15,000 to 1/17,000. Among patients with traumatic persistent vegetative state, 33% are dead at one year and among those with non-traumatic persistent vegetative state 53% are dead at one year.

Vegetative State: A Case Report

A video was presented of a patient followed for the last eight years, who suffered anoxia from seizures and an allergic reaction to a drug given during her fourth delivery. She has remained in a vegetative state since the complication occurred. In the video it is clearly seen that she is lying in her bed in a fetal position with her eyes closed; however, unexpectedly and without stimulus she opens her eyes, yawns, grimaces and moves her head. Then upon clapping she blinks as if showing a startle response that appears consistent when she repeats the blinking upon clapping again. No sign of awareness of the environment was ever demonstrated in her despite the presence of her relatives and children. This patient is a clear case of persistent vegetative state and because of her long evolution without change and non-traumatic etiology, she probably could accurately be called a ‘permanent’ vegetative patient.

Recovery from the Vegetative State in the Media

The cases of 'dramatic' recovery from vegetative state often reported in the media should be discussed carefully and in depth. In general these cases are not well documented and no medical records are available. Also, in most, the etiology of the neurological cause of the vegetative state is unclear. However, late recoveries do exist and have been reported in the scientific literature and the variables in these reports are not significantly different from those in the media. The major difference is that well reported recoveries always have severe sequelae, which is not clarified in the media reports. Considering the significant prevalence of vegetative state, the total number of recoveries is relatively small and, again, there are no well-documented cases that have recovered to a normal life after being vegetative for more than a month or two.

The most studied and publicized case of permanent vegetative state is that of Karen Ann Quinlan, a woman who, in April 1975, suffered brain anoxia from ingesting a combination of barbiturates, benzodiazepines and an excessive amount of alcohol. She entered a persistent vegetative state and was kept alive with artificial feeding and ventilation. Later that year her parents went to court requesting permission to disconnect the respirator and by January 1976 the New Jersey Supreme Court granted permission to suspend respiratory support. However, the patient continued to breathe on her own (the respiratory centers in the lower brainstem were intact) and died ten years later on June 15th 1986.

The Quinlan case is different from those reported about men and women who had 'fully recovered' to the point of 'talking' to their families after spending years in a vegetative state. In such patients, it is likely that even in the best scenario for recovery, language as well as the capacity for clear articulation of words would probably remain severely affected. Most importantly, patients who have indeed recovered significantly were probably in the 'minimally conscious state' – a condition which will be discussed by Professor Stephen Davis from Australia – and represent patients that should be strictly differentiated from individuals in a vegetative state, since they do have some degree of preserved consciousness that obviously carries major implications for care and prognosis.

A case that recently brought up a very delicate and different issue was that of Terry Schiavo, a woman who had been in a persistent vegetative state for more than a decade after she suffered brain hypoxia from a cardiac arrest and in whom her husband had decided to discontinue feeding

(Figure 9, see page 419). In contrast to the case of Karen Quinlan, where discontinuation of ventilatory support did not result in the death of the patient, withdrawal of feeding would inevitably result in death, thus raising a very sensitive ethical issue. The US Supreme Court refused the appeal by the Governor of the State of Florida (J. Bush) and allowed Terry Schiavo's husband to discontinue feeding. The patient died soon after this measure was implemented.

The American Academy of Neurology had published a consensus of opinion in 1989 regarding this type of decisions, stating that artificial nutrition and hydration are forms of medical treatment such as the indication of antibiotics or any other medication (Figure 10, see page 419) [6]. Secondly, there was agreement in that no medical or ethical distinctions should be made between withholding or withdrawing treatment. No doubt there is a major psychological difference for the caregiver, and for the physician or nurse, between deciding not to give an antibiotic (i.e. withholding a medication) and withdrawal (i.e. discontinuing) of the tube used to feed and hydrate a patient. In the latter case it is acknowledged that, although the physician knows that by discontinuing feeding the patient will die, this does not imply that the physician's intention is the death of the patient. The argument used to accept discontinuation of feeding is that, in properly evaluated cases, the physician can define whether feeding or other means of support are actually prolonging death and not life. Once medical treatment fails to sustain a patient's well being and proves to be of no benefit to the patient and the family, there is no longer an ethical obligation to provide it. When artificial nutrition is discontinued, death occurs approximately within two weeks as a result of dehydration and from alterations in potassium, sodium and other electrolytes, but not from malnutrition. It is important to emphasize that patients do not experience thirst or hunger since by definition they are vegetative and not aware of these feelings. When feeding is discontinued some patients that are in a vegetative state may progress into a coma before they die.

Misdiagnosis of the Vegetative State

It is difficult to imagine a more horrifying situation than having completely lost the capacity for expression and movement while retaining consciousness and awareness and not being able to transmit this to the surrounding world. The book *The Count of Montecristo* by Dumas describes a character, Monsieur de Noirtier, Count of Villefort, who suffered what Dr.

Jerome Posner – present at this conference – dubbed the 'Locked-in State'. In this situation, patients have a lesion in the ventral pons – a section of the brainstem – where all motor fibers are localized together in a relatively small space and thus, when this area is injured, the result is complete paralysis of the body. Only blinking or partial eye movements can be preserved with full coexisting consciousness despite the severe degree of paralysis. An emotional description about the experience of living in a locked-in state is found in the book *The Diving Bell and the Butterfly* published by the editor of a French fashion magazine who died after dictating his experience with the use of a blinking-based alphabetic system.

Surprisingly and of concern, misdiagnosis is not unusual in the vegetative state. Andrews *et al*. reported in the *British Medical Journal* in 1996 that, from a total of 40 patients admitted to their specialized rehabilitation unit in England, 40% were misdiagnosed as being in the persistent vegetative state, when they were actually in a minimally conscious state and thus able to communicate [7]. The authors reported that patients were able to develop consistent means of communication using eye movements or a special touch-sensitive buzzer system in their rehabilitation unit. The most frequent reasons reported as why patients had been misdiagnosed in a vegetative state were 1) their severe physical disability, 2) presence of blindness, 3) confusion with the terminology used, 4) examination by inexperienced physicians (it should be emphasized that vegetative states are not commonly seen by the general physician) and, 5) an insufficient period of observation. The authors emphasized that experienced physicians should examine every patient in detail and repeatedly, that families, caregivers and nurses should be meticulously interviewed, and that the medical records should thoroughly read looking for anything that would suggest that the patient may be severely impaired but not vegetative.

When a patient is transitioning from a vegetative to a minimally conscious state (a usual pattern of improvement) the first function to be recovered is visual pursuit (i.e. following objects or people with the eyes purposefully). This function should not be confused with the random eye movements seen in a vegetative person. The caveat, however, is that since almost 50% of patients in the report by Andrews (and in a significant proportion of all vegetative cases) were blind or severely visually impaired, then visual pursuit will obviously not be a useful clinical marker to determine a state of minimal consciousness.

Do Patients in a Vegetative State 'Feel'?

Only a few hours before this meeting took place, Owen *et al*. published in *Science* a report directly relevant to the question of 'perception' and 'feeling' in vegetative patients (Figure 11, see page 420) [8]. They examined with functional MRI (magnetic resonance imaging) a woman who had been 5 months in a persistent vegetative state after suffering traumatic brain injury in a traffic accident. Normally, following an adequate stimulus, functional MRI reveals activation of specific brain regions. The authors told the patient to imagine herself playing tennis or walking in her house and to their surprise MRI lighting was noted in the pre-motor cortex, reflecting activity in that region with no differences when compared to normal controls. Moreover, the investigators told the patient an ambiguous sentence ('the creak came from a beam in the ceiling') and noticed that she had an additional response in accessory language regions, similar to that observed and registered in normal volunteers. This further supported the possibility of comprehension, since activity in these secondary language areas occurs when the semantic processing necessary for equivocal language understanding is initiated. A similar type of cortical activation as that reported by Owen *et al*. has also been shown in partially conscious patients, during sleep and under anesthesia, suggesting that the results do not necessarily implicate full consciousness. However, the brain activity elicited when the authors talked to the patient about playing tennis, or when they asked the patient to take a tour around her house, suggests some degree of conscious processing of those commands. Further research will be needed before fully understanding the meaning of these findings in one single case. Adding to the debate, Owen's patient showed some visual pursuit activity at eleven months of follow up, which suggests that at that moment she was in a minimally conscious state. It could thus be proposed that functional MRI may predict which patients in a vegetative state will recover to a minimally conscious state allowing for tailored rehabilitation techniques and pharmacological treatments.

The different motor (body movements), autonomic (sweating, tachycardia), and endocrinological phenomena observed in vegetative patients are reflex responses to stimuli or pain but are not a sign indicative of pain perception. These nociceptive mediated subcortical responses may elicit grimacing and crying-like behaviors similar to those seen in consciousness but in this scenario are mediated by thalamic and limbic system circuits, which do not involve consciousness. Clinical experience supports that there is no behavioral indication suggesting that vegetative patients feel pain or suffer. Post-mortem neuropathology findings of extensive bilateral brain necrosis are inconsistent with the capacity of feeling, moving or making conscious gestures. Positron emission tomography (PET) images show a severe reduction in cortical glucose metabolism incompatible with the capacity to feel pain or any other emotions.

The question about whether patients in a vegetative state suffer or feel is valid due to the fact that these patients grimace, cry and have different types of facial reactions to various stimuli. The topic has been well studied and, excluding patients with a misdiagnosis, it can be defined that pain and suffering are conscious experiences, and therefore unconsciousness – which is a prerequisite in the vegetative state – precludes these feelings.

MOVEMENTS IN BRAIN DEATH

For almost four decades the medical profession has expressed consensus regarding the diagnosis of brain death. This unanimous opinion accepts that the diagnosis of irreversible and complete loss of brain function (i.e. brain death), in a body with preserved circulatory function due to a ventilator or any other means of artificial support, is death. Misunderstanding and confusion may arise from the term 'brain death' since it may suggest that there are two types of death, that only the brain may be dead or that death is 'incomplete'. As Bernat has pointed out, to reduce the possibility of misinterpretations, it should be kept in mind that 'death' is a non-technical word, that it is irreversible, that it represents a biological phenomenon, that it is an event and not a process (there is a process in dying and another one of disintegration following death itself) and that death can be accurately determined by physicians [9].

The occurrence of movements in a dead person is no doubt a counterintuitive phenomenon. A priori, a comment implicating movement in a dead body would only be acceptable as a headline in yellow journalism (Figure 12, see page 420). Naturally, the notion of death is associated with no movements and the purpose of describing the fact that movements can occur serves to emphasize a caveat in brain death diagnosis. It is generally easy for anyone who sees a picture of a dead soldier in a battlefield or a body at the site of an accident, to understand that the image shows a dead person (Figure 13, see page 421). However, if the image shows a brain dead body awaiting organ harvesting for transplantation purposes, lying on an ICU bed connected to a ventilator and other machines with active nurses in that setting, it would be difficult for anyone – including medical personnel – to understand and accept that this is the image of a dead person (Figure 14, see page 421). So it is indeed reasonable that movements be perceived as a contradiction of death.

There are recollections as early as in the 16th century, describing a surprised Vesalius when he opened a thorax during an autopsy and noted that the heart was still beating as staggering evidence of an erroneous diagnosis of death. On the other hand, during some cardiac surgeries, for technical reasons the heart is paralyzed but this does not implicate that the patient has died (Figure 15, see page 422). It is a common experiment in medical school to kill a frog and take the heart from the body, put it on a dish with saline solution and watch, to the amazement of medical students, that the heart continues to beat for minutes or hours. In this example, the presence of movement does not mean the frog is alive but rather reveals 'automatism' as one of the heart muscle's properties.

A controversy has been generated regarding the presence of movements in brain death and that this could question the diagnosis of death. There are well-known clinical observations of body movements that are compatible with a diagnosis of brain death. These include spinal cord reflexes that are present in approximately 80% of patients up to 200 hours from brain death diagnosis [10]. These movements include the cremasteric, abdominal or plantar reflexes as elicited by an examiner. Also complex movements of the limbs have been reported as representing spinal automatisms. These are movements integrated at the level of the spinal cord without any influence from the brainstem or brain. Martí-Fabregas reported 2 out of 400 patients who had a diagnosis of brain death and showed ventilator-synchronized decerebrate posturing-like movements [11]. Because the patients had a diagnosis of brain death, by definition they could not have 'decerebrate' movements that imply some degree of brain activity. The authors were reporting not only that patients had movements that resembled those seen in comatose (live) patients, but also the fact that these movements were coordinated with the ventilator rhythm. Ropper reported respiratory-like movements without clinically functional significance during the apnea testing for certification of brain death [12]. These movements may occur spontaneously and also with stimulation during tube and other device removal from the dead body usually within minutes from the determination of death. Urasaki *et al.* studied the origin of movements in brain death and reported preserved spinal dorsal horn potentials with an absent cortical response, confirming the isolated origin of these movements in the spinal cord [13]. Other responses that can be integrated in the spinal cord in brain dead patients generating from spinally mediated vasoconstriction or even adrenal gland stimulation include sweating, flushing, hypertension, tachycardia and other cardiovascular phenomena. In another report, Saposnik *et al*. commented on spontaneous and reflex movements on brain death and found that, among 38 patients with this diagnosis, 39% had different movements including finger jerks, undulating toe flexion, plantar responses, facial myokimia, and, as the most impressive, the so-called 'Lazarus' sign' (Figure 16, see page 422) [14]. In the latter, the patient – usually provoked with stimulation by head or neck flexion – seems to incorporate in the bed, raises the arms crossing them in the midline and extends the fingers. It is important to keep in mind the possibility that these movements may occur while devices are being disconnected from the dead body to warn medical and paramedical personnel and, more importantly, the family. In some instances, it is appropriate to consider using the injection of neuromuscular blocking agents to prevent these movements. It is unusual to see movements beyond 24-48 hs after brain death diagnosis. Movements observed at the surgical table during organ harvesting have been used as the argument to question the reliability and validity of the concept of brain death.

From the aforementioned discussion one can conclude that, in this context, death is not necessarily a synonym of immobility and movements can be seen in certain patients with recent diagnosis of brain death. These movements do not question the accuracy of a brain death diagnosis.

In his book *Descartes' Errors*, Antonio Damasio states 'we are, and then we think, and we think only inasmuch as we are, since thinking is indeed caused by the structures and operations of being' [15]. This statement elegantly reflects with a neuroscientific as well as a philosophical view the concept of consciousness, lack of consciousness and losing personhood according to whether a person is in a healthy state, with an injured brain or at the extreme of brain death. Not only it is difficult for a family member or even medical staff to accept a movement in a dead body but it has also been difficult for society as a whole to accept the concept of brain death mainly because it is rather recent in world history.

If adaptation to new concepts is the problem, it is then appropriate to quote the former President of the United States, Thomas Jefferson, when he said that 'I am not an advocate for frequent changes in laws and constitutions, but these must go hand in hand with the progress of the human mind. As new discoveries are made, new truths discovered and opinions change, institutions must advance also to keep pace with the times. We might as well require a man to wear still the coat which fitted him when a boy as civilized society to remain ever after the regimen of their barbarous ancestors'.

I would like to conclude using an analogy to once again lay emphasis on the purpose of this meeting at the Pontifical Academy of Sciences. It has been extensively discussed in different contexts that the fertilized ovum has no life and has no brain in the first minutes, days, or weeks from conception. However, the critical distinction to be made is that the fertilized ovum is a 'being' precisely because it has a future, as do all of us present here during this conference today. In the fertilized ovum exists a life with a future and, on the other hand, what we shall be discussing in this meeting is not life with a future but only that which in the past was a person and now is only a body with organs that are being kept functioning only due to the effectiveness of modern technology. A body that seems to host a person but no longer does and organs that in their artificial functioning only contribute to the loss of dignity of the whole body. This is exactly the point. If a diagnosis of brain death has been made, we should not stand for the artificial prolongation of the functions of a heart, liver, or a kidney, in a body that is already a corpse with absolutely no hope either in the present or in the future.

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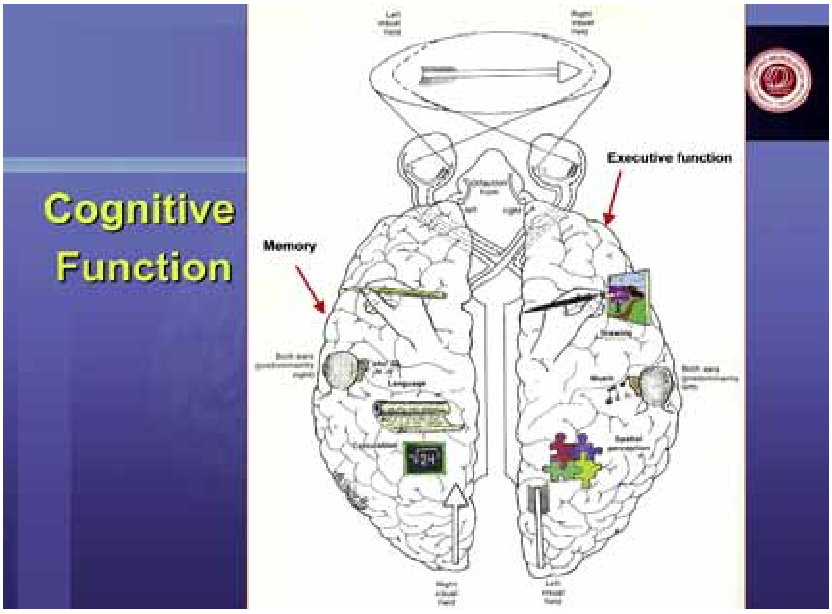
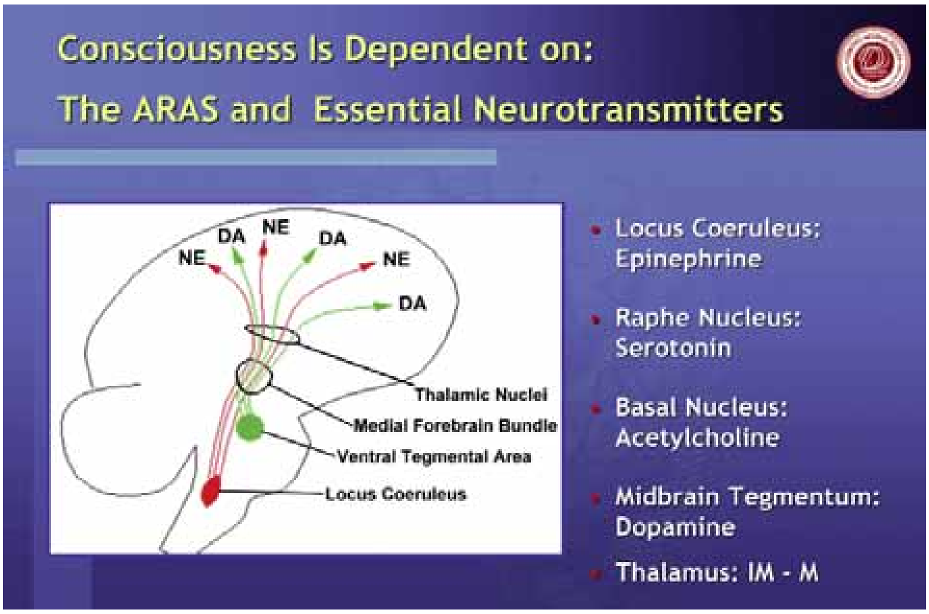


Figure 1.



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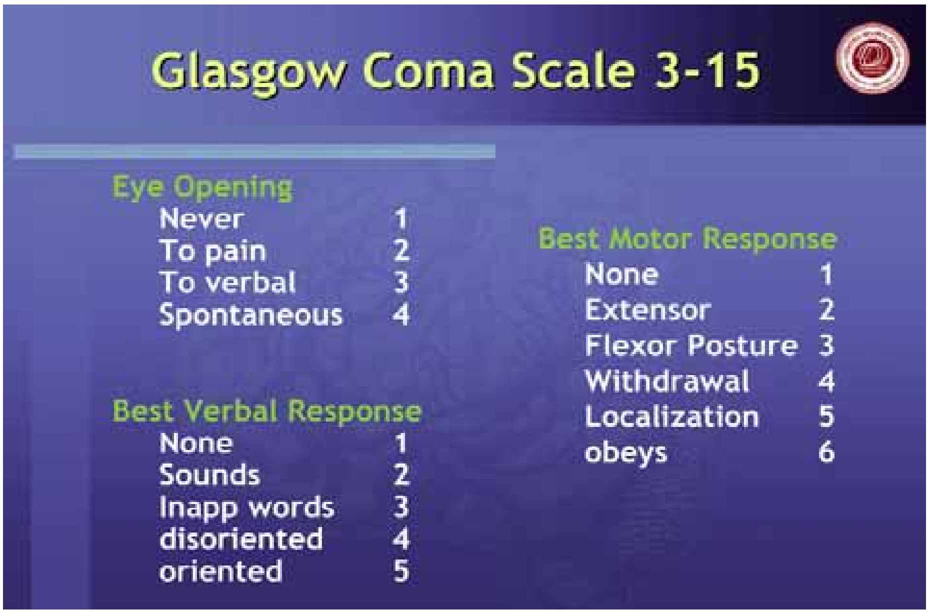

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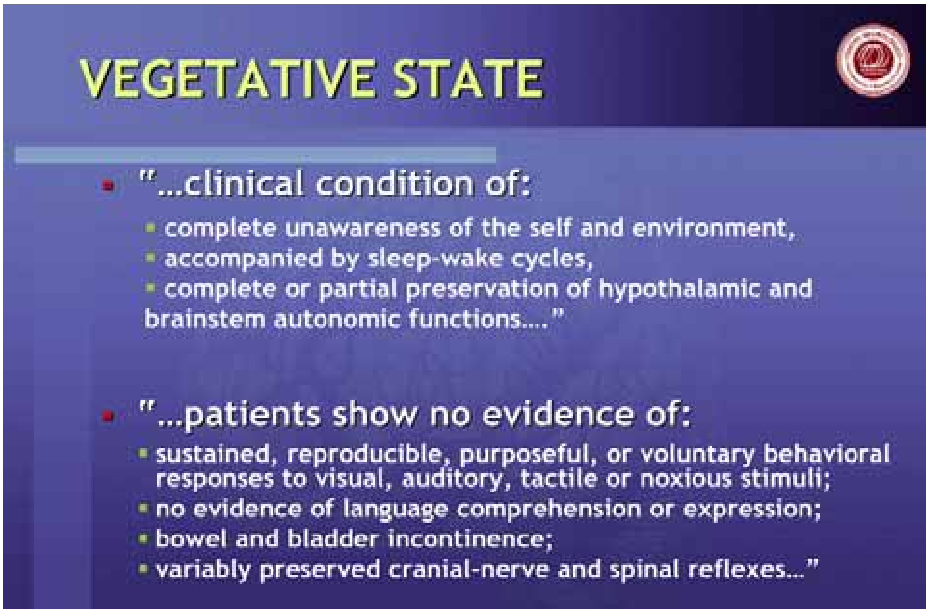

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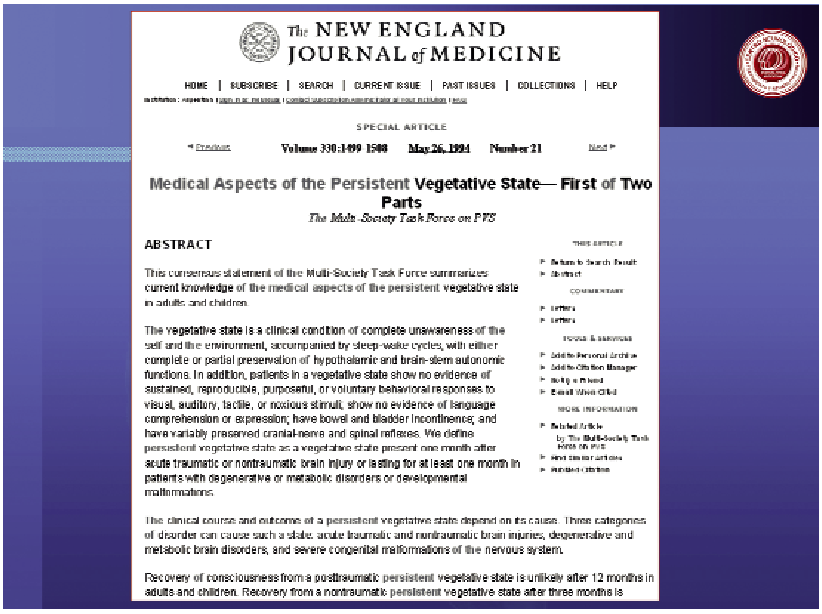

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SPECIAL ARTICLE

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Medical Aspects of the Persistent Vegetative State— First of Two Parts

The Multi-Society Task Force on PVS

ABSTRACT

This consensus statement of the Multi-Society Task Force summarizes current knowledge of the medical aspects of the persistent vegetative state in adults and children.

The vegetative state is a clinical condition of complete unawareness of the self and the environment, accompanied by sleep-wake cycles, with either complete or partial preservation of hypothalamic and brain-stem autonomic functions. In addition, patients in a vegetative state show no evidence of sustained, reproducible, purposeful, or voluntary behavioral responses to visual, auditory, tactile, or noxious stimuli; show no evidence of language comprehension or expression; have bowel and bladder incontinence; and have variably preserved cranial-nerve and spinal reflexes. We define persistent vegetative state as a vegetative state present one month after acute traumatic or nontraumatic brain injury or lasting for at least one month in patients with degenerative or metabolic disorders or developmental malformations.

The clinical course and outcome of a persistent vegetative state depend on its cause. Three categories of disorder can cause such a state: acute traumatic and nontraumatic brain injuries, degenerative and metabolic brain disorders, and severe congenital malformations of the nervous system.

Recovery of consciousness from a posttraumatic persistent vegetative state is unlikely after 12 months in adults and children. Recovery from a nontraumatic persistent vegetative state after three months is

Figure 5.

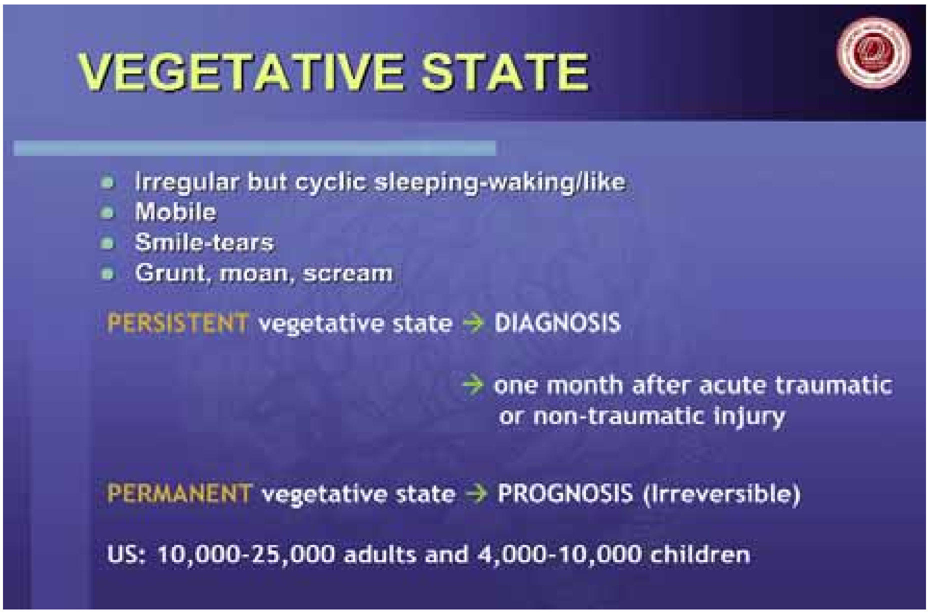

Figure 6.

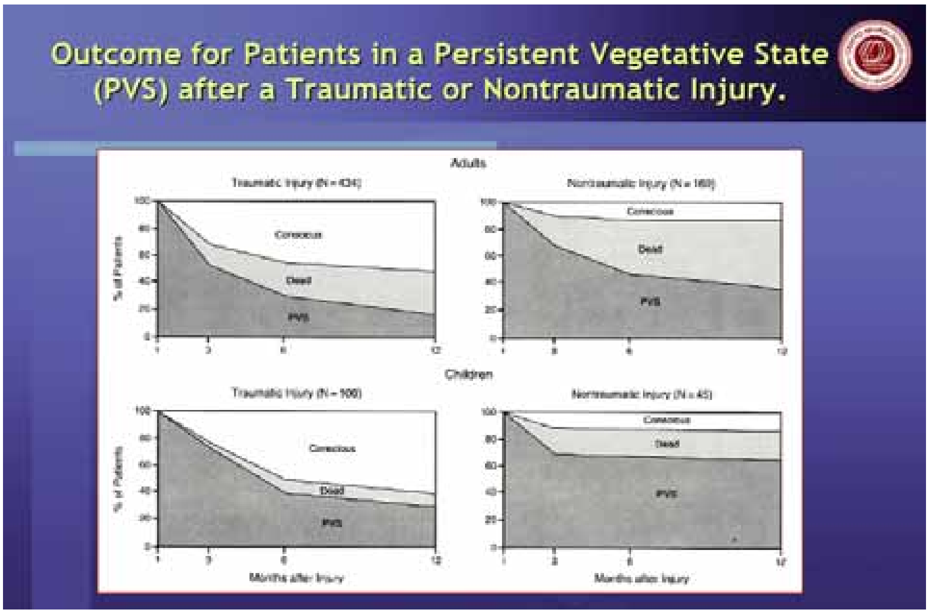

Figure 7.

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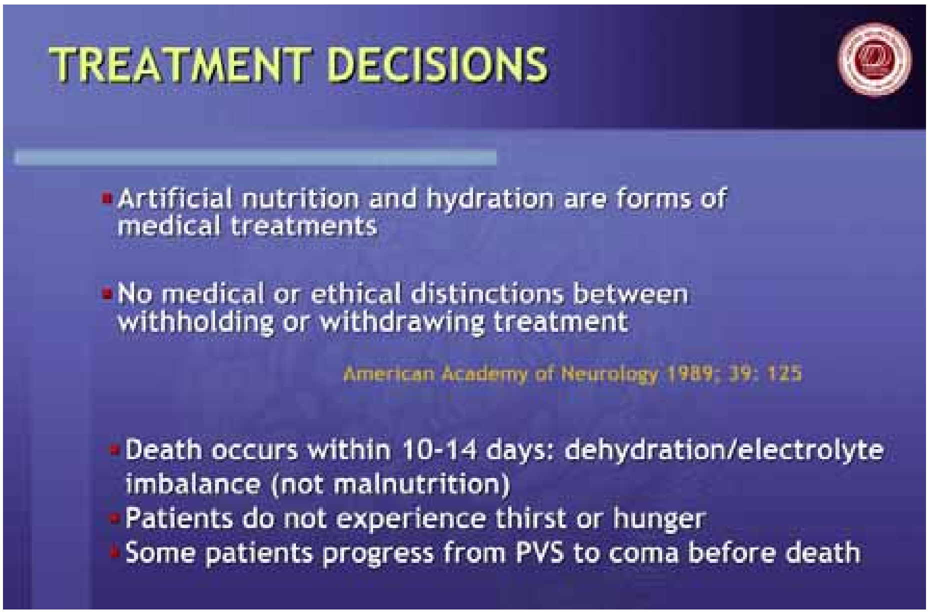
PRACTICE PARAMETER: ASSESSMENT AND MANAGEMENT OF PATIENTS IN THE PERSISTENT VEGETATIVE STATE
(Summary Statement*)

Table 2. Probability of Recovery of Consciousness and Function at 12 Months in Adults and Children in a Persistent Vegetative State (PVS) Three or Six Months after Traumatic or Nontraumatic Injury.*

OUTCOME	ADULT Traumatic (N = 434)	ADULT Nontraumatic Injury (N = 169)	CHILDREN Traumatic Injury (N = 106)	CHILDREN Nontraumatic Injury (N=45)
	% of patients (99% confidence interval)			
Patients in PVS for 3 months+				
Death	35 (27-43)	46 (31-61)	14 (1-27)	3 (0-11)
PVS	30 (22-38)	47 (32-62)	30 (13-47	94 (83-100)
disability	19 (12-26)	6 (0-13)	24 (8-40)	3 (0-11)
Moderate disability or good recovery	16 (10-22)	1 (0-4)	32 (15-49)	0
Patients in PVS for 6 months++				
Death	32 (21-43)	28 (12-44)	14 (0-31)	0
PVS	52 (40-64)	72 (56-88)	54 (30-78)	97 (89-100)
disability	12 (4-20)	0	21 (1-41)	3 (0-11)
Moderate disability or good recovery	4 (0-9)	0	11 (0-26)	0

Figure 8.

Figure 9.



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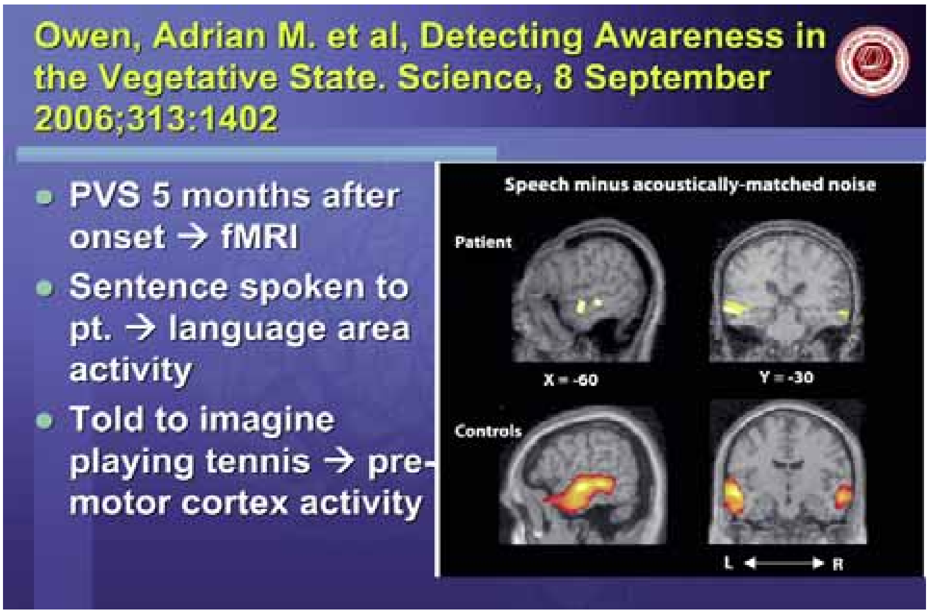


Figure 11.

Figure 12.

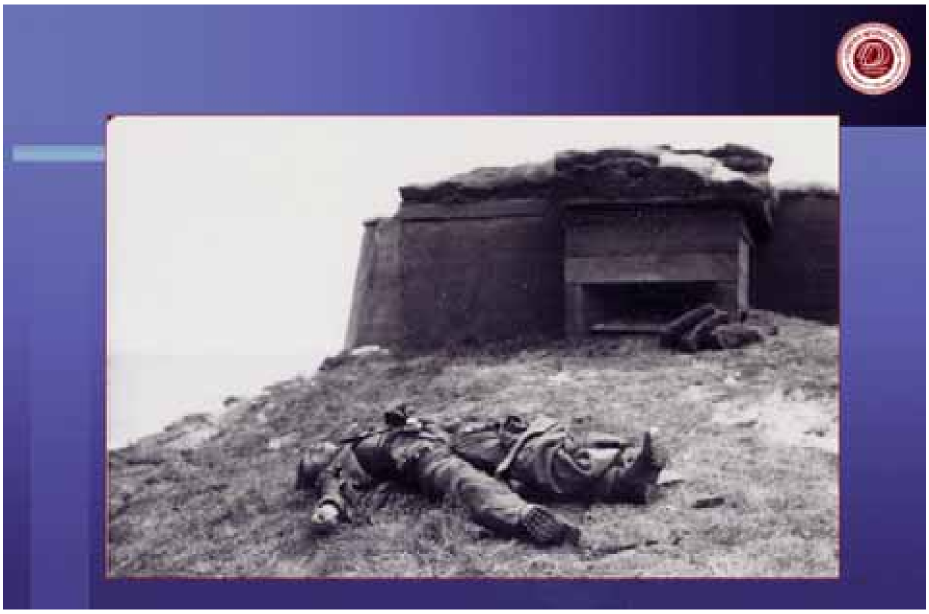
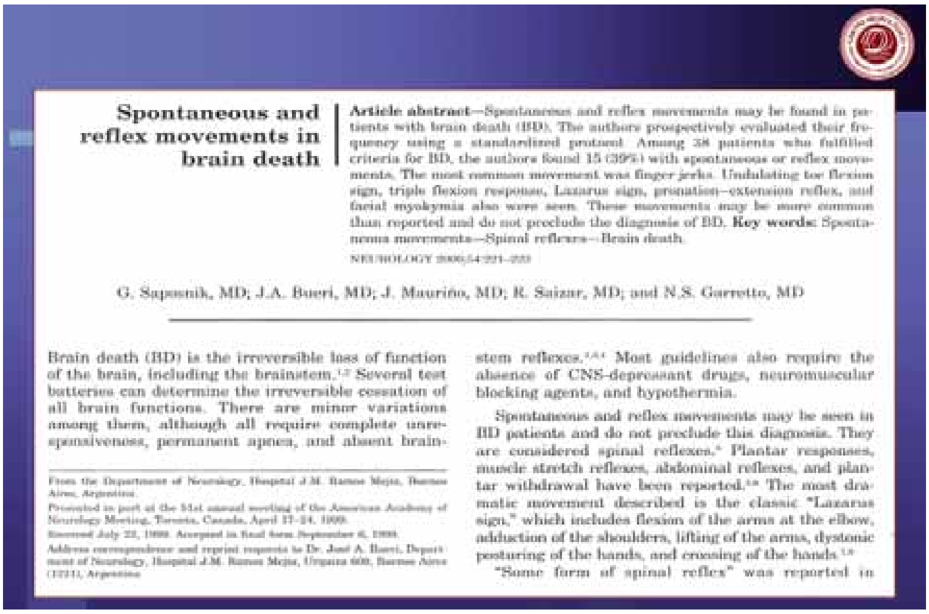


Figure 13.

Figure 14.

Figure 15.



Spontaneous and reflex movements in brain death

Article abstract—Spontaneous and reflex movements may be found in patients with brain death (BD). The authors prospectively evaluated their frequency using a standardized protocol. Among 38 patients who fulfilled criteria for BD, the authors found 15 (39%) with spontaneous or reflex movements. The most common movement was finger jerks. Undulating toe flexion sign, triple flexion response, Lazarus sign, pronation–extension reflex, and facial myokymia also were seen. These movements may be more common than reported and do not preclude the diagnosis of BD. **Key words:** Spontaneous movements—Spinal reflexes—Brain death.

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Brain death (BD) is the irreversible loss of function of the brain, including the brainstem.[1,2] Several test batteries can determine the irreversible cessation of all brain functions. There are minor variations among them, although all require complete unresponsiveness, permanent apnea, and absent brainstem reflexes.[1,3,4] Most guidelines also require the absence of CNS-depressant drugs, neuromuscular blocking agents, and hypothermia.

Spontaneous and reflex movements may be seen in BD patients and do not preclude this diagnosis. They are considered spinal reflexes.[4] Plantar responses, muscle stretch reflexes, abdominal reflexes, and plantar withdrawal have been reported.[5,8] The most dramatic movement described is the classic "Lazarus sign," which includes flexion of the arms at the elbow, adduction of the shoulders, lifting of the arms, dystonic posturing of the hands, and crossing of the hands.[1,8]

"Some form of spinal reflex" was reported in

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Figure 16.