

The clinical diagnosis of brain death

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Key words: brain death, diagnostic criteria, heartbeat.

Death has been analysed in a heterogeneous way, according to the theological, philosophical and scientific concepts of the world. Until recently death was diagnosed following the cessation of the functions of the heart and lungs. Currently, the ability to maintain cerebral function with mechanical support, in the absence of spontaneous breathing and heart beat, and the power to ensure circulation and respiration, despite the complete destruction of the brain, demand a redefinition of death. There is now the concept of brain death. In this paper we discuss the concept of death, from ancient times to the modern criteria for brain death. The historical definition will be discussed, and the new criteria for diagnosing brain death will be explained.

Introduction

The word "death" comes from the Latin word *mors* and has various synonyms such as *decease*, *demise* and *expiration*. Some define it as a cessation or termination of life, life being accepted as the period of time from birth to the death of an organic being. In the Terminological Dictionary of Medical Sciences², it is recognised as the termination of local, molecular and natural life, and life is defined as a state of activity of organised beings.

Different ways of analysing death do not always correlate well. Each method aspires to define and

to know the death phenomenon. To define a person as dead presupposes that no medical treatment is possible in order to reverse the situation of cessation of life. Nowadays there is world-wide debate about the multiplicity of death concepts³⁻⁸.

Until recently, death was accepted following cessation of the functions of the heart and lungs. Currently cerebral function can be maintained with mechanical support, in the absence of spontaneous breathing and heart beat. The circulation and respiration can also be maintained despite massive brain damage. This has necessitated redefinition of death using neurological criteria, but the topic has been the subject of intense debate. The concept of brain death is vital because of modern transplant techniques and the need for donor organs.

This paper details the concept of death from ancient times to the modern criteria for brain death. Historical aspects in the diagnosis of death are discussed, as are the new concepts of brain death.

Historical aspects in the diagnosis of death

Diagnosing death is a problem as old as humanity itself. In ancient times respiration was regarded as the most important factor and when a patient stopped breathing he was dead. Halakhal⁹ (recompilation of religious precepts) stated that death coincides with the cessation of breathing movements.

In ancient Greece doctors thought that death could originate from the head, the lungs or from the heart, but the heart was the place where life was based. It was the first organ to start living and the last to die¹⁰. These doctors felt that the heart beat distinguished the states of life or death and it was the definitive vital sign. Despite this their confidence in this diagnosis was not absolute. Claudio Galeno acknowledged that there were cases in which the application of his definitions (and being guided by signs defined by him) could lead to errors in diagnosis. He included hysteria, suffocation and catalepsy among the states that could suspend all signs of life¹¹.

In the middle of the 17th century, the personal doctor of the Pope Paulo Zacchias stated that no signs could clarify the diagnosis of death, apart from the appearance of putrefaction phenomena. Many people must have been buried alive. This concern for live burials found a response a century later. The anatomist Jaques Benigne Wislow published a text about the uncertainty of death signs. It was due to fear of premature burial that Englishman George Batenson, manufacturer of boxes or coffins with emergency bells, became rich. He was granted an Order of the British Empire by Queen Victoria¹¹.

In 1627 William Harvey described the circulation, and the heart beat was scientifically established as the other sign of life. Since then death has been clinically defined as the "cessation of cardiac beatings"¹². In 1819 Leannec invented the stethoscope and contributed the auscultation technique to the veracity of the diagnosis.

In late 1950 European neurologists defined a coma stage in which the brain stops functioning from irreversible damage, but it is still possible to keep the heart and lungs functioning through artificial means. Mollaret and Goulon¹³, lecturers at Claude Bernard Hospital in Paris in 1959, called this condition "coma depasse". They described a state beyond coma where there is the association of a "dead brain and a live body"¹³. These authors referred to the dilemma of delimiting the "ultimate frontiers of life". Current medical technology and the establishment of modern intensive care units have changed the old concept of death as a cessation of heart beat. Resuscitation techniques enable us

to save patients after periods of cardiac asystole which can last for some minutes. Whilst short-term respiratory depression meant death until a few decades ago, nowadays modern ventilation systems make it possible to deliver an adequate supply of oxygen for an undetermined period.

In 1967, in Cape Town, Denise Anne Duval suffered an accident, and severe brain damage. Hours later the cardiac surgeon, Christiaan Barnard, extracted her still beating heart to transplant it into Louis Washkansky¹⁰. This event marked a qualitative jump in the development of transplants. There is special relevance in the correct and precocious diagnosis of brain death, to have at one's disposal viable organs. It is common knowledge that the more recently an organ is donated, the higher the probability of its survival. There is therefore the need to be able to diagnose brain death, rather than death following the cessation of respiration and cardiac action. Brain death is defined as the "irreversible cessation of brain functions, that is, of the brain hemispheres, of the brainstem and the cerebellum"^{12,14,15}. The concept of brain death is now readily accepted by doctors.

Criteria for the diagnosis of brain death

The Harvard criteria of brain death were established in 1968, but diagnostic criteria have varied from one country to another^{6,8,12,17}. Walker considered that ideal criteria should have the following characteristics¹².

- they should be simple, uniform and can be interpreted by any medical doctor,
- produce non-graduated and unequivocal results,
- be compatible with traditional methods of determining death,
- be accepted by the general public and
- examine multiple functions in order to have a minimal possibility of error.

In a general sense the following criteria are accepted¹⁷⁻²⁴:

- 1 Deep coma without any kind of response.
- 2 Irreversible and irreparable brain injury
- 3 Absence of brainstem and spinal integrated reflexes
- 4 Negative atropine test
- 5 Proved apnoea with an apnoea test.
- 6 Electroencephalogram results (optional test)
- 7 Observation period

does not produce sounds spontaneously and does not respond to externally applied stimuli.

- 2 Irreversible and irreparable brain injury. There should be an antecedent of severe brain trauma, a vascular accident, a primitive tumour of the nervous system or another condition diagnosed with clinical or complementary examinations. Reversible forms of coma should be excluded such as poisoning, drugs, hypothermia, and shock^{12-14,19}.
- 3 Absence of brainstem and spinal integrated reflexes. In the brainstem there are twelve pairs of cranial nerves, which constitute the afferent and efferent channels of local reflexes. These reflexes highlight the integrity of the brainstem and their absence is a synonym of functional loss of this structure. The reflexes include the pupillary reflex to light, corneal reflexes, the "doll's eye" phenomenon and the gag reflex.
- 4 Atropine Test Two mg of atropine sulphate is injected intravenously, and the pulse is monitored for a period of 15 seconds, and after 5, 10 and 15 minutes. There is no confirmation of brain death if there is an increase of more than 5 beats per minute¹⁹.
- 5 Apnoea: A patient undergoing machine controlled ventilation who makes no effort against the ventilator for a period of 15 minutes may be considered brain dead. Further proof comes with the test of apnoeic oxygen^{15,25}. This last test should only take place when the remaining criteria are observed and minimal ventilation movement excludes the diagnosis of brain death.
- 6 Electroencephalogram This is an optional test which evaluates electrical brain activity. Some authors defend the need to confirm electrical brain silence in order to diagnose brain death. In the criteria established by the Harvard Committee¹⁶, this test is included as the fifth one. In the United Kingdom and other countries²⁶⁻²⁸ it is considered that the diagnosis of irreversible death of the brainstem is enough to infer death of the brain, and therefore, death of the

clinical procedures, without the need for instrumental techniques.

There are different views regarding the importance of the EEG in the study of brain death. Even industrialised countries, such as the USA and United Kingdom, have different criteria.

- 7 Observation period. The criteria to establish brain death should be present during a 30 minute observation period and in a second examination 6 hours later.

Confirmatory evidence can be obtained for a precocious diagnosis. After observing and fulfilling criteria 1 to 5, the need for an observation period can be eliminated if it is possible to get electrical-physiological evidence confirmed by the evoked potential and by the electroretinogram.

The potentials evoked are electrical responses in the form of variations of the voltage which is obtained in electrodes placed along the nerve channel. An appropriate stimulus is given to the receptor and a bio-electrical response is obtained. Among these tests are the auditory evoked potential of the brainstem, the short latency somatosensorial test of the median nerve, visual evoked potentials and the electroretinogram. For each one there are specific patterns of brain death²⁹⁻³³. Cerebral angiography studies have also been used in order to evaluate brain circulation. According to some authors, the elective method is cerebral panangiography^{33,34}.

In the Harvard Committee report¹⁶ it was established that when brain death criteria are followed, spinal reflexes are absent. Other studies have shown that these reflexes, obtained by muscular stretching or provoked by cutaneous stimuli, can be present³⁵⁻³⁷. Thus spinal reflexes lack value in the diagnosis of brain death.

Patients who are brain dead may, in addition to spinal reflexes, have other abnormal movements. Most of the time these are provoked by proprioceptive or cutaneous stimuli, and less frequently they appear spontaneously. The movements lack intention and are stereotyped. Ivan³⁵ observed a type of motor

reflex response of spinal origin provoked by a sudden flexion of the neck and characterised by a flexion of the arms and legs, or contraction of the abdominal muscles. A similar motor response was analysed by Ropper³⁸ in five cases in which passive flexion of the head caused elevation of the four extremities.

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