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REVIEW

The evolution from the diagnosis of death to encephalic death

La evolución del diagnóstico de la muerte hasta la muerte encefálica

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ABSTRACT

Introduction: death is a process whose diagnosis has varied with historical evolution.
Objective: to demonstrate the different ways of diagnosing death until reaching encephalic death.
Methods: a historical documentary review of the different ways of diagnosing death is carried out.
Results: in ancient times the most important thing was breathing, when a person stopped breathing he/she was dead, then clinical death emerged and the heartbeat took the primary place, when the heart stopped death was diagnosed. At the end of 1950, European neurologists highlighted a stage in which the brain had ceased to function, presenting irreversible damage, but the functions of the heart and lungs could be maintained by artificial means. Mollaret and Goulon, professors at the Claude Bernard Hospital in Paris, in 1959, called this condition "coma dépassé", and clarified that it was a state beyond coma where "a dead brain is associated with a living body", thus the concept of encephalic death emerged and the diagnosis of death began to be made under the prism of the functions of the brain which has allowed the development of organ and tissue transplants.
Conclusions: at present, death can be diagnosed by the cessation of heart functions or by the irreversible cessation of brain functions.

Keywords: Brain; Brain Death; Cardiac Arrest; Respiration; Organ Transplantation.

RESUMEN

Introducción: la muerte es un proceso cuyo diagnóstico ha variado con la evolución histórica.
Objetivo: demostrar las diferentes formas de diagnosticar la muerte hasta llegar a la muerte encefálica.
Métodos: se realiza una revisión histórica documental sobre las diferentes formas de diagnosticar la muerte.
Resultados: en la antigüedad lo más importante era la respiración cuando una persona dejaba de respirar estaba muerta, luego surgió la muerte clínica y los latidos cardiacos ocuparon el lugar primordial, al detenerse el corazón se diagnosticaba la muerte. A fines de 1950, neurólogos europeos destacaron un estadio en que el encéfalo ha dejado de funcionar, presenta un daño irreversible, pero se pueden mantener por medios artificiales las funciones del corazón y los pulmones. Mollaret y Goulon, profesores del Hospital Claude Bernard de París, en 1959, llamaron a esta condición «coma dépassé», y aclararon que se trataba de un estado más allá del coma donde se asocia «un cerebro muerto, a un cuerpo vivo», así surgió el concepto de muerte encefálica y el diagnóstico de la muerte comenzó a realizarse bajo el prisma de las funciones del encéfalo lo cual ha permitido desarrollar los trasplantes de órganos y tejidos.
Conclusiones: en la actualidad la muerte puede ser diagnosticada por la parada de las funciones del corazón o por el cese irreversible de las funciones del encéfalo.

Palabras clave: Encéfalo; Muerte Encefálica; Parada Cardiaca; Respiración; Trasplante de Órganos.

INTRODUCTION

Since ancient times, death has been a topic of research for scientists. Death is perceived as a part of a process rather than an isolated event, and its interpretation has depended on each individual's conception of the world. For some, it represents end (cessation), while for others, it represents fulfillment (plenitude), a break-up (change), or transformation (ultimate realization).

This heterogeneity arises because the various ways of analyzing death not always coincide, let alone fully complement each other. Each of them aspires to internalize, know and possess the phenomenon of death. Defining the death of a person assumes that medical treatment cannot reverse the cessation of life.

For centuries, human death was traditionally understood as the cessation of heart and lung functions. Currently, it is possible to keep heart and lung functions with mechanical assistance even in the absence of brain function. This has led to a mandatory redefinition of death.

The development of modern transplant techniques and organ procurement, as well as the growth of intensive care units, have led to a new perspective on the phenomenon, thus giving rise to the concept of brain death.

This new concept has enabled the advancement of activities associated with organ and tissue transplantation. It is important to understand that brain death, which is defined as the irreversible cessation of all brain functions, is not a distinct form of death, but rather an interpretation of death based on brain function.[1] As a result, death can now be diagnosed using either the traditional method of cardiac arrest or by determining that the brain has ceased to function.

DEVELOPMENT

Historical progression from “conventional” death to the concept of brain death

Breathing was of utmost importance to people in ancient times. When a person ceased to breathe, they were considered dead. According to the Halakhah, which is a collection of religious precepts, death is defined as the cessation of respiratory movements. To determine if a human being had died, a mirror was placed close to their nose looking for any condensation. If no condensation was found, the individual was considered dead.[2]

In Greece, physicians believed that death could originate in the head, lungs, or heart. However, they considered only the heart as the site where life resided. According to their beliefs, the heart was the first organ to begin functioning and the last to die. They believed that heartbeat distinguished between life and death.

The heartbeat was the only definitive vital sign. However, their confidence in this diagnosis was not absolute. Similarly, it is noteworthy that Claudius Galen, an ancient physician, recognized the possibility of diagnostic errors even when applying his own definitions and recommended signs. He listed hysteria, asphyxia, coma, and catalepsy as examples of conditions that could temporarily suspend all signs of life.

During the 16th century (in 1546), the Spanish physician Miguel Servet made a major discovery by describing the pulmonary circulation, also known as the lesser circulation. Many years later, in the 17th century, precisely in 1628, Sir William Harvey announced that blood circulates in a perpetual circular motion. This discovery led to the establishment of the heartbeat as a scientific sign of life through the description of the greater circulation. From that point on, it was clinically suggested that death occurs with the cessation of heartbeat.[3] By the mid-17th century, some physicians argued that putrefaction was the true indicator of death, resulting in the potential burial of many individuals who were not actually dead. This theory gained popularity due to the widespread fear of early burial. In England, George Bateson, a coffin maker who designed coffins with emergency bells, became wealthy and was awarded the Order of the British Empire by Queen Victoria.[2]

At the end of the 18th century (1799), Xavier Bichat, a prominent French physician cited by Laín Entralgo, published his book *Physiological Research on Life and Death*. To write the book, he relied on dissecting corpses of citizens executed by guillotine, and emphasized: “I had access to them 30-40 minutes after the execution.”[4] Bichat, who is considered one of the founders of the tissue theory, distinguished two parts when referring to nervous tissue: the nervous system of life of relation and the vegetative nervous system. The former is characterized by being voluntary, while the latter is involuntary. This distinction allowed Bichat to classify life into two types: animal life and organic life. Both are quite distinct, as they do not appear in the process of human development simultaneously, nor do they disappear simultaneously.

Bichat observed that in the process of natural death, life ceases before organic functions disappear. According to the scientist, the heart is traditionally referred to as the *ultimum moriens* [2] because it is the last organ to stop functioning in natural death caused by a long-term illness. However, in cases of accidental death, the heart ceases to function before the brain. That is the difference between death due to old age and death resulting from a sudden hit. In the former, life begins to decline in the whole body, except for the heart, where it ends. While in the latter, life decreases first in the heart and then in the remaining parts. Therefore, death

effects occur from the center outward.

In 1819, René Théophile Hyacinthe Laënnec invented the stethoscope, which improved the accuracy of diagnosing death by assessing heart function through the technique of auscultation. Years later, the debate regarding the phenomenon that resulted in early burial resurfaced, with two positions being discussed. The first position presented the concept of suspended animation, which is a phenomenon identical to death,[5] where living organisms come to a complete stop and then restart, similar to a pendulum clock. This position suggests the necessity of redefining death to differentiate it from suspended animation.

On the other hand, the second position stated that suspended animation did not actually result in a complete suspension of body functions. Instead, body functions continued in a form and degree that were imperceptible to the observer. If this is true, the issue is not redefining death, but rather being able to diagnose it. Therefore, it is necessary to have the means to differentiate between death and minimal functioning of organs and body systems. Consequently, the theory of suspended animation was abandoned in favor of the second theory, which states that life ends if vital functions cease. Therefore, the problem was to find more precise and accurate techniques for identifying the existence or non-existence of essential body functions. Several methods were proposed to determine if a patient was alive, including holding a feather near the nostrils or placing a container of liquid on the chest. If the patient was breathing, the chest would move, causing the liquid in the container to move. The debate surrounding the definition of death persisted, and doubts soon arose about accepting heartbeat a true sign of death.

In 1898, the French surgeon Tuffier successfully restored the heartbeat of a young man who had undergone an appendectomy and experienced cardiac arrest five days later.[6] However, the revival of heart activity did not become a reality until the 1940s, when pharmacological and electrical means were used to control heart rhythm. In 1947, the first successful electrical defibrillation was performed on a patient who had been in ventricular fibrillation for 70 minutes. At the same time, extensive research on coma was conducted. In the late 1950s, European neurologists identified a stage at which the brain has ceased to function, exhibiting irreversible damage. However, artificial means can sustain the functions of the heart and lungs. In 1959, professors Mollaret and Goulon from the Claude Bernard Hospital in Paris introduced the term "coma *dépassé*" to describe a state beyond coma, where a "dead brain is associated with a living body." [8] Throughout evolution, the ancient conception of death as the cessation of heartbeat came into contradiction. Resuscitation techniques can save patients even after their hearts have stopped for several minutes.

Undoubtedly, a major event in this evolutionary process took place on December 3, 1967, in Cape Town, South Africa. As a result of a traffic accident, Denise Anne Darvall suffered severe traumatic brain injury with brain rupture. Hours later, the patient was urgently transferred to Groote Schuur Hospital, where the renowned cardiac surgeon Christian Barnard, with the assistance of Hamilton Naki, removed her beating heart for transplantation into Louis Washkansky, a 52-year-old shopkeeper who was on the verge of dying due to heart failure.[9] In a remarkable 48-hour surgical procedure, the two teams successfully removed the young woman's heart and implanted it into Washkansky's body. This event is a significant milestone in medical history and marks a qualitative leap in the development of transplants. The advancements in this field emphasize the importance of accurate and early diagnosis of brain death to ensure the availability of suitable organs. As it is already known, the likelihood of survival increases with the prompt acquisition of an organ.

A significant event occurred a year later with the publication of the Report of the Harvard Medical School Ad Hoc Committee (1968), which introduced the well-known Harvard Criteria for defining irreversible coma. Over time, criteria for brain death have emerged, defining it as the irreversible cessation of all brain functions. This concept is now widely accepted. [10-14] From the early days of neurosurgery as a specialty, Harvey Cushing conducted studies on brain death and proved the significance of intracranial hypertension in its pathophysiology. [15]

Based on the aforementioned considerations, it is valid to highlight that death can be diagnosed today either by cardiac arrest or by the cessation of all brain functions. When diagnosing brain death or the cessation of all brain functions, organ and tissue transplantation may become possible. In cases of brain death, where an individual is considered deceased and becomes a cadaver, their organs and tissues can be used to restore lost functions in other patients by replacing the organs or tissues.

The transplant procedures are heavily reliant on the willingness of the donor's family to consent to the extraction of organs and tissues. It is important to provide ethical education based on the principles of solidarity, as well as the bioethical principles of beneficence, autonomy, and justice. In several countries, regulations and decrees have been established to allow healthcare professionals to perform these procedures with legal support. The following section will examine Cuba's stance on this issue.

A quest for legislation for brain death

In the pursuit of legislation regarding brain death, it's important to note that since 1987, the World Health Organization (WHO) has acknowledged the necessity of developing legal guidelines concerning brain

death. The World Health Assembly approved Resolution 40, urging a thorough review of the legal and ethical aspects related to this crucial medical activity. Due to the need to establish legal guidelines, it is essential for legislatures to carefully review this process to ensure the protection of citizens' rights and compliance with ethical considerations. In Cuba, there are several legal entities that safeguard scientific activities related to brain death. The Constitution of the Republic of Cuba states in Article 49: Everyone has the right to receive healthcare and be protected. [16] This establishes the necessary guarantees to fulfill this important principle. The Law No. 41 of July 13, 1983 on Public Health is the main legal provision that guides health matters. As stated in Article 4 of this law: The proper utilization of advancements in global medical science and technology. [17]

The concept of brain death in Cuba is legally established by Decree No. 139 of 1988, which regulates the Public Health Law. [18] According to the aforementioned legal provisions, when diagnosing brain death, the following aspects should be considered:

- The diagnosis should be conducted by qualified personnel responsible for performing such a procedure, in accordance with the regulations set forth in the Public Health Law, its Regulation, and other applicable provisions.
- The medical certificate of death shall be issued in accordance with the provisions of the law in force. The established requirements and formalities must be fulfilled as soon as the diagnosis of death is issued.
- The medical procedures associated with this diagnosis will be performed by a different team than the one responsible for organ and tissue transplantation.
- Before performing the surgical procedure, it is necessary to confirm the diagnosis according to the Cuban criteria established by the Ministry of Public Health (MINSAP in Spanish) and reflected in the official model provided by the organization (correctly prepared and signed by the attending physicians). Additionally, it is important to verify if the donor has authorized organ donation on their identity card and ensure that all documentation related to the donor is complete and correctly prepared.

The legal effects of a diagnosis of brain death are equivalent to those of any other type of death, as previously stated. Once brain death is confirmed, organs and tissues can be procured because the individual is considered deceased and is therefore a cadaver. Article 26 of the Cuban Civil Code takes a practical and technical approach. The death of a person is determined and certified by authorized medical personnel in accordance with regulations established by the competent authority. [19]

Only medical professionals are responsible for certifying death as they possess the scientific knowledge required to diagnose it. The certification of death and subsequent transplantation can only proceed after medical personnel have confirmed that the criteria for diagnosing brain death have been met. The exact moment of death, which must be recorded in the legal document, is when a team of specialists confirms that the Cuban criteria for diagnosing brain death have been met. This is crucial in the legal field when viewed through the lens of succession law. Certifying death is crucial for the surgical extraction of organs and is an essential prerequisite for the procedure. Article 83 of Decree No. 139 of 1988, Regulation of the Health Law, states: All medical procedures related to organ and tissue transplantation from donors must be certified according to a strict anatomy-based diagnostic criteria established by the Ministry of Public Health, in accordance with the law. [18]

In September 2001, the Ministry of Public Health published Resolution No. 90 in the Official Gazette of the Republic of Cuba, which masterfully covers the topic of brain death. This resolution is a significant social achievement as it legalizes all aspects related to the determination and certification of death through a Ministerial Resolution instead of a law issued by parliament. This facilitates future reevaluations and changes according to scientific and technical advancements.

In general, the legal basis for Cuban criteria for diagnosing brain death and, consequently, for organ transplantation can be summarized as follows:

- Organ, blood, and tissue donation is a voluntary act carried out by the donor or their representative.
- It is an action performed for humanitarian purposes.
- Organ donation is allowed for mentally sound individuals who are 18 years of age or older. In cases involving minors, authorization from their father, mother, or legal guardian is required in their absence.
- The decision to donate organs and tissues should be documented on the donor's identification card.
- If the deceased did not indicate their decision to donate organs and tissues on their identity card, authorization from their parent, guardian, or legal representative is required.
- The significance of this essential intervention will always be discussed with the family beforehand, and they will be informed accordingly.
- The medical procedures are performed exclusively for therapeutic purposes, specifically for treating other patients.
- All medical procedures related to diagnosing brain death and transplanting human organs and tissues

will be performed by highly qualified personnel.
- The Ministry of Public Health will identify the healthcare units authorized to perform organ and tissue transplants within the National Health System.

CONCLUSIONS

The diagnosis of death has evolved over time. In ancient times, breathing was considered the crucial factor in distinguishing between life and death. However, today, the diagnosis of brain death is used. Brain death is characterized by the irreversible cessation of brain functions, including the cerebral hemispheres, brainstem, and cerebellum. The nervous system is the most complex organization in the human body. In cases of brain death, it is demonstrated that the nervous system has ceased to function. Therefore, an individual who meets the specific criteria for a brain death diagnosis is considered deceased.

In current medical practice, death can be diagnosed by either cardiac arrest, the cessation of heart function, or the cessation of brain function. In Cuba, physicians are solely responsible for diagnosing brain death and certifying the fact of death due to their scientific knowledge. Legal frameworks exist to protect all scientific activities related to brain death, organ, and tissue transplantation.

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FINANCING

None.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

Conceptualization: Ricardo Hodelín Tablada.
Research: Ricardo Hodelín Tablada.
Methodology: Ricardo Hodelín Tablada.
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