



Determination of death by neurologic criteria worldwide – religious, ethical and legal issues. A review

Rozpoznawanie śmierci według kryteriów neurologicznych na całym świecie. Dylematy religijne, etyczne i prawne. Praca przeglądowa

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Abstract

Introduction. Death must be determined according to established medical criteria, which includes either the irreversible cessation of circulatory and pulmonary functions or the irreversible cessation of all brain functions. Brain death/death by neurologic criteria (BD/DNC) is defined as the complete and permanent loss of brain function, including unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently.

Objective. The aim of this review was to establish the differences in the determination of brain death worldwide, as well as the ethical, religious, and legal dilemmas associated with the determination of brain death.

Review Methods. Pubmed and Google Scholar databases were searched using key words. Original articles in English, published between 2015–2024 were included. Articles that did not meet the selected criteria were excluded.

Brief description of the state of knowledge. Numerous studies have shown that there is variability in the determination of BD/DNC, both internationally and intranationally. This leads to the situation in which a patient may be considered deceased in one location, but not in another.

Summary. Differences in protocols for determining brain death exist globally, and while efforts towards standardization are underway, certain aspects still require improvement. The endeavour to unify protocols worldwide faces challenges due to ethical and religious disparities. While these protocols offer legal guidance to physicians and may reduce liability, they do not absolve medical professionals of ethical obligations. Physicians must prioritize patient welfare and be confident that brain death criteria are ethically justified and free from external pressures.

Key words

death by neurologic criteria, brain death criteria, brain death determination

List of abbreviations

BD/DNC – Brain death/death by neurologic criteria; CPR – cardiopulmonary resuscitation; PPV – positive pressure ventilation; UDDA – The Uniform Determination of Death Act; AAN – The American Academy of Neurology; EEG – encephalography; CT – computed tomography; PET – positron emission tomography; PaCO₂ – arterial partial pressure of carbon dioxide; MAID – medically assisted in dying

Streszczenie

Wprowadzenie i cel pracy. Śmierć należy rozpoznawać na podstawie ustalonych kryteriów medycznych, które obejmują nieodwracalne ustanie czynności układu krążenia i płuc albo nieodwracalne ustanie wszystkich funkcji mózgu. Śmierć mózgu/ śmierć według kryteriów neurologicznych definiuje się jako całkowitą i trwałą utratę funkcji mózgu, która obejmuje śpiączkę z utratą przytomności, odruchy pniowe i zdolność do samodzielnego oddychania. Celem niniejszego przeglądu było ustalenie różnic w rozpoznawaniu śmierci mózgu na świecie, a także dylematów etycznych, religijnych i prawnych związanych z ustalaniem śmierci mózgu.

Metody przeglądu. Za pomocą słów kluczowych przeszukano bazy danych Pubmed i Google Scholar. Uwzględniono artykuły oryginalne w języku angielskim, opublikowane w latach 2015–2024. Artykuły, które nie spełniały wybranych kryteriów, zostały wykluczone.

Opis stanu wiedzy. Liczne badania wykazały, że istnieją różnice w rozpoznawaniu śmierci mózgu/ śmierci według kryteriów neurologicznych zarówno w skali międzynarodowej, jak i wewnątrz krajowej. Prowadzi to do sytuacji, w której w jednym miejscu danego pacjenta można uznać za zmarłego, a w innym już nie.

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Podsumowanie. Na całym świecie istnieją różnice w protokołach rozpoznawania śmierci mózgu i chociaż trwają wysiłki zmierzające do ich standaryzacji, niektóre aspekty nadal wymagają poprawy. Próba ujednoczenia protokołów na całym świecie napotyka wyzwania wynikające z rozbieżności etycznych i religijnych. Chociaż protokoły te oferują lekarzom wskazówki prawne i mogą zmniejszyć odpowiedzialność, nie zwalniają one pracowników służby zdrowia

z obowiązków etycznych. Lekarze muszą stawiać dobro pacjenta na pierwszym miejscu i mieć pewność, że kryteria śmierci mózgu są uzasadnione etycznie i wolne od nacisków zewnętrznych.

Słowa kluczowe

kryteria śmierci mózgowej, rozpoznawanie śmierci mózgowej, śmierć według kryteriów neurologicznych

INTRODUCTION

Death must be determined according to established medical criteria which include either the permanent halt of circulatory and respiratory functions, or the permanent halt of brain functions [1]. Brain death/death by neurologic criteria (BD/DNC) is defined as the complete and permanent loss of brain function which include unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently. This condition can arise due to the permanent cessation of oxygenated circulation to the brain or as a consequence of devastating brain injury [2]. In this context, 'permanent' signifies the loss of function that will not spontaneously return, and cannot be restored through intervention [3]. The term 'brain death' is commonly used by both the general public and healthcare professionals. Death by neurologic criteria describes the method of determining death more accurately [2].

Before the 1950s, the prevailing notion of death focused on the cessation of cardiorespiratory function; consequently, it was widely assumed that cessation of brain function followed the cessation of respiration and circulation, making the loss of brain activity a fundamental aspect of death. However, the emergence of advanced life support techniques, such as cardiopulmonary resuscitation (CPR) and positive pressure ventilation (PPV) in subsequent years challenged this interconnected view and the traditional definition of death [4]. The breakthrough came in 1947 with Claude Beck's first successful human defibrillation, and in 1950, the invention by Bower and Bennett of positive pressure ventilation. Subsequently, individuals experiencing cardiorespiratory arrest were able to recover from what was previously considered 'death' [5]. In 1959, the French neurologists Mollaret and Goulon introduced the concept of brain death, initially termed '*le coma dépassé*'. They described a state characterized by apnea, coma, absence of brainstem reflexes, and no detectable electroencephalographic activity [4]. However, it is important to note that they did not equate this state to the death of the entire person. In 1968, the Ad Hoc Committee of the Harvard Medical School in the USA proposed the Harvard Brain Death Criteria, outlining clinical and electroencephalographic criteria for diagnosing brain death. This was a pivotal moment in medical history because it introduced a clinical framework for defining death beyond traditional cardiorespiratory criteria. Later, in 1981, the Uniform Determination of Death Act (UDDA) in the USA formally recognized this concept, allowing for the declaration of death based on either neurologic criteria or traditional cardiopulmonary standards. This legal recognition solidified the acceptance of neurologic criteria as a valid means of determining death within the medical and legal systems [6].

More recently, in 1995, the American Academy of Neurology (AAN) took a significant step forward when it released evidence-based practice parameters, later updated in 2010. These parameters established a comprehensive, step-by-step approach to determining brain death in adults, providing a unified and algorithmic framework for healthcare professionals [7]. In 2012, an international collaboration, including the World Health Organization (WHO), convened to address the concept of BD/DNC. The consensus reached at this forum was that brain death is equivalent to death itself, and advocated for a shift in perspective so that all forms of death, including those following cardiac arrest, are understood as being brain-based [8]. In 1987, guidelines for determining brain death in paediatric patients were established by the American Academy of Paediatrics. These guidelines, with updates issued in 2011, specifically address the unique considerations and protocols necessary for assessing brain death in children, providing valuable guidance to healthcare providers working with the paediatric population [4].

DESCRIPTION OF THE STATE OF KNOWLEDGE.

Numerous studies have shown that there is variability in the determination of BD/DNC, both internationally and intranationally. This leads to the situation in which a patient may be considered deceased in one location, but not in another [9].

OBJECTIVE

The aim of this review is to establish the differences in the determination of brain death worldwide, as well as the ethical, religious, and legal dilemmas associated with the determination of brain death.

MATERIALS AND METHOD

Pubmed and Google Scholar databases were searched using the key words: 'Brain death criteria around the world', 'brain death – religious issues' and 'brain death – legal issues'. Original articles in English published between 2015–2024 were included. Articles that did not meet the selected criteria were excluded.

Brain death determination – criteria around the world. In 2020, Lewis A. et al. published the most extensive study to date on global protocols for determining brain death, after contacting 136 countries (42% of the world). A protocol for

the determination of BD/DNC existed in only 83 countries and there were 78 individual –?-. In 62 protocols, a definition of death was provided, with 54 referring to whole-brain death and 8 to brainstem death. Information about the number of examiners was available in 61 protocols, with the majority requiring at least 2 examiners. Obligatory qualifications for at least 1 examiner were specified in 68 protocols (Tab. 1).

Table 1. Obligatory credentials for at least 1 examiner [8]

Examiner	Protocols (n=78)	Protocols n%
Neurologist	38	49
Neurosurgeon	30	38
Licensed doctor	23	29
Anesthesiologist	21	27
Intensivist	14	18
Physician responsible for the hospital	5	6

Approximately 54% (42) of the 78 protocols indicated that the person performing the determination of BD/DNC ought not to be affiliated with the transplant team. In 53 protocols, the number of examinations was mentioned, with 44 requiring at least 2 examinations. The study highlighted variations in the components of clinical examination (Tab. 2).

Table 2. Clinical examination components [8]

Component of clinical examination	Protocols (n=78)	Protocols n%
Coma	70	90
Pupillary reflex	70	90
Corneal reflex	68	87
Oculovestibular reflex	67	86
Gag reflex	64	82
Cough reflex	62	79
Oculocephalic reflex	58	74
Facial noxious stimuli	37	47
Limbs noxious stimuli	22	28

The apnea test was required in 71 (91%) protocols, with only 2 addressing the procedure for patients on ECMO – extracorporeal membrane oxygenation. An ancillary test was required in 22 (28%) of the protocols, with conventional angiogram and EEG – electroencephalogram – being the most commonly used (Tab. 3).

Table 3. Accepted ancillary tests [8]

Ancillary test	Protocols (n=78)	Protocols n%
Conventional angiogram	72	92
EEG	72	92
Transcranial ultrasound	56	72
Nuclear study	47	60
Evoked potential	40	51
CT angiogram	31	40
MR angiogram	15	19

In 9 protocols, there was a recommendation for clinicians to engage in dialogue with the families prior to suspending

organ support. The time of death was defined in 45 protocols, with 30 (66%) occurring immediately after completion of the clinical examination, 4 (9%) at the moment an ancillary test was analyzed, 1 (2%) when an ancillary test was conducted, and 11 (24%) at a different time [8]. In 2015, a previous international study by Wahlster et al. which collected data from 91 countries, found that 70 (36% of the world) had an institutional protocol for brain death. Notably, the prevalence of these protocols varied with economic status (Fig. 1). The study also highlighted that countries with a well-organized transplant network were more inclined to have provisions addressing brain death, compared to those without such a network [7].

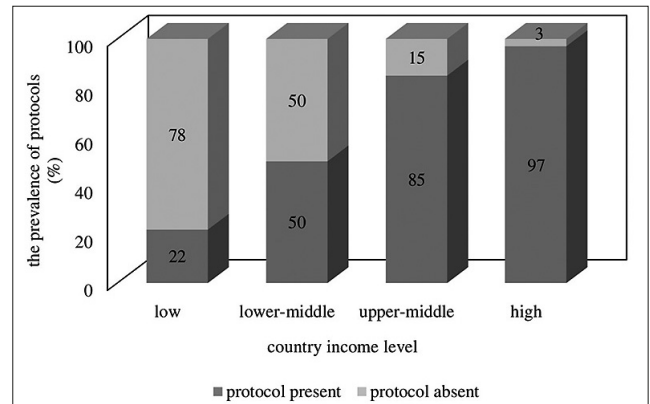


Figure 1. Prevalence of brain death protocol depending on the economic status of the country [7]

Considerable research has been carried out regarding variations in brain death criteria intranationally. In 2016, an analysis was performed of death according to neurologic criteria involving 492 individual hospitals or systems in the USA. Notable disparities included the exclusion of hypotension (56%) and hypothermia (79%), comprehensive specifications of the clinical examination and apnea testing, and clear guidelines regarding ancillary tests and their execution. Of the 492 policies, 163 (33.1%) necessitated specific expertise in neurology or neurosurgery for the healthcare professional responsible for determining brain death, and 212 (43.1%) specified that the determination should be made by an attending physician. 150 policies did not provide information regarding the qualifications of the person who decides such a determination [10].

Efforts to standardize criteria. Although the determination of BD/DNC is widely accepted globally, disparities in policies at national and international levels have spurred efforts to align practices and fundamental concepts, both within and among nations [11]. To this end, in 2020, in an investigation entitled 'The World Brain Death Project', efforts were made to establish the essential clinical criteria necessary for diagnosing brain death. The authors conducted a literature review across the significant databases to identify essential articles released from July 2017 – April 2020.

Before beginning the process of BD/DNC determination, it is crucial to confirm that the patient has an established neurologic diagnosis that can lead to the complete and irreversible loss of all brain function. Conditions and diseases, such as core temperature, blood pressure, toxins, disturbances in metabolism, acid-base balance, and hormonal

regulation, need to be ruled out. Assessment of BD/DNC can be conducted through clinical evaluation demonstrating coma, brainstem areflexia, and apnea, and should primarily rely on clinical testing. The examination should demonstrate the size of pupils and their reaction to light; absence of reflexes: corneal, oculocephalic and oculovestibular; no facial response to cranial noxious stimuli; absence of gag reflex when both sides of the posterior pharynx are stimulated, absence of cough reflex in response to deep suctioning of the trachea; no motor reaction controlled by the brain to noxious stimuli of the limbs; and no spontaneous breathing observed when the apnea test results show a pH below 7.30 and PaCO₂ above 60 mm Hg. When a clinical examination cannot be performed, additional tests, such as blood-brain flow studies and an electroencephalogram (EEG) are necessary. Every stage in determining brain death should be thoroughly documented, using a standardized checklist [2].

Although the World Brain Death Project provided detailed insights into diagnosing BD/DNC, there were unresolved issues regarding remaining brain functions, the nature of complex reflexes, the effectiveness and risks of apnea testing, overlooked factors like central hormonal dysfunction and high-cervical-spinal-cord injury, challenges in the effectiveness of additional diagnostic tests, and cases where brain death findings could be reversible. Moreover, the project proposed different concepts of death without solid justification, including restating brain death criteria, considering personhood beyond brain function, and suggesting integral physiological responses of the entire organism. These metaphysical discussions were unclear, and the project did not provide a convincing argument justifying the reason why the state described as BD/DNC should be equated with death itself [12].

A notable revision of the criteria was made by Shemie et. al. in Canada which resulted in some changes in the guidelines. They recommended a unified concept of death predicated on the irreversible cessation of brain activity, encompassing the absence of consciousness and brainstem reflexes, including the capability for autonomous breathing. This cessation can occur due to the halt of blood circulation or from traumatic brain injury. Moreover, the primary cause of severe brain injury must be corroborated by neuroimaging findings consistent with the acknowledged cause. For patients with hypoxic-ischemic injury who lack imaging evidence indicative of profound brain injury, the clinical evaluation for determination of death by neurological criteria should be postponed for 48 hours following the return of spontaneous circulation post-cardiac arrest.

Oculocephalic reflex is not recommended as a part of the clinical assessment. Infratentorial brain injury without significant supratentorial involvements does not meet the criteria for death by neurological criteria and necessitates additional investigation. Four-vessel angiography and encephalography is no longer recommended. Most investigations have primarily relied on observational methods, leaving many critical clinical inquiries unanswered due to the absence of direct evidence. Information specifically pertaining to paediatric cases, patients undergoing medically assistance in dying (MAID), and individuals who have undergone decompressive craniectomy, remains generally scarce.

Areas requiring further investigation have been pinpointed, encompassing topics such as determining minimal pulse

pressures for optimal brain blood flow, understanding the progression of brain injury leading to death, and enhancing the precision of clinical examination techniques, such as apnea testing and additional tests [13].

The guidelines maintain a focus on a careful and methodical process, leaning towards caution, in order to minimize the risk of incorrectly identifying BD/DNC [11]. However, some recommendations lack strong evidence, warranting further research, for example, there is a need for prospective studies examining the clinical features of DNC in post-cardiac arrest patients. It is recommended that a single DNC clinical assessment is conducted by 2 clinicians in the adults group; however, this approach has not been adequately studied on patients with decompressive craniectomy. Additionally, there are gaps in understanding the mechanism and timing of potential reversibility of DNC features in this population. It is necessary to clinically assess and document the absence of brainstem reflexes, but further research is needed to update the ranked significance of specific brainstem reflexes confirming DNC in different populations. Gaps in knowledge also exist regarding apnea testing, including the optimal PaCO₂ threshold and the potential harm of hypercarbia induced by the test. Future studies should explore the impact of positive airway pressure on the accuracy of DNC and the acceptance of apnea testing by the family. Furthermore, investigations comparing causes and mechanisms of death between patients with and without residual endocrine function or thermoregulation, may provide valuable insights [14].

Religious Issues. Religion plays a significant role in shaping beliefs and practices surrounding end-of-life care, including decisions regarding BD/DNC. BD/DNC is commonly accepted across many religious traditions, although the level of acceptance varies among and within different religious groups [2]. In Buddhism, while some scholars accept BD/DNC as a form of death, this viewpoint is not universally endorsed. Christianity exhibits diverse perspectives among its denominations: American Baptists, Anglicans, Seventh-day Adventists, Southern Baptists, United Methodists, and Unitarian Universalists generally have no official stance against using neurologic criteria for determining death, while Evangelicalism acknowledges the irreversibility of BD/DNC and suggests removing life support to facilitate the dying process. Jehovah's Witnesses and Lutherans hold mixed opinions, whereas Presbyterianism and Roman Catholicism generally accept BD/DNC as death. The range of Christian views regarding death determined by neurological criteria stems from various communal interpretations of these concerns and ongoing scientific debates.

In Hinduism, BD/DNC is accepted as death by some authorities, though not universally. In Islam, Shiism tends to accept BD/DNC as death, while Sunnism shows mixed opinions. Within Judaism, Conservative and Reform Judaism generally accept BD/DNC as death, while Orthodox Judaism holds mixed opinions [15]. These varied perspectives reflect the complexity of religious beliefs and their intersections with medical definitions of death [2].

Ethical issues. Shewmon argues that the current mainstream concept of brain death is inconsistent, with discrepancies between the criteria, tests, and practical outcomes. These inconsistencies raise fundamental questions about whether

brain death truly equates to the death of the organism as a whole, or if it merely represents an irreversible coma [16]. Skowronski et al. conducted a scoping review of the literature, identifying 32 studies which examine attitudes toward death by neurologic criteria. The majority of these studies concentrated on the perspectives of healthcare professionals and university students, with only 6 focusing on broader population samples. The findings revealed that in the majority of the studies, approximately 75% of respondents acknowledged brain death as synonymous with the death of the individual. Less frequently observed viewpoints included considering death equivalent to irreversible coma, and expressing willingness to undergo organ donation even if it resulted in death [17].

Following determination of BD/DNC, despite the permanent cessation of brain function, the body of the deceased individual may still exhibit warmth and vital biological functions, such as heartbeat, circulation, digestion and excretion, which might persist due to technological support. This situation can induce uncertainty and immense stress among family members, impairing their decision-making abilities and rational thinking [18]. The persistence of such biological functions challenges the notion that brain death truly represents the end of the organism as a whole. Cases have emerged where brain-dead patients have shown signs of homeostasis, proportional growth, and overcoming intercurrent illnesses, further complicating the understanding of brain death as a clear biological endpoint [16]. Joffe et al. highlight that current clinical and ancillary tests cannot definitively confirm irreversible loss of all brain functions due to potential confounders [19].

In 2023 Paquette et al. conducted a study aimed at investigating and evaluating the experiences of physicians who refused to accept brain death determinations. Refusals can stem from various reasons related to patients with acute or progressive brain injuries. Through surveys and interviews, consistent reasons for refusals emerged, such as hoping for a miraculous recovery, reluctance to let go, religious objections, and skepticism regarding the concept of brain death. Additionally, requests for extended time to gather family members, allow end-of-life rituals, or await a perceived miracle were significant factors contributing to refusals [20]. When families reject the determination of death, it presents complex ethical dilemmas. However, delivering news of death with honesty and empathy can facilitate acceptance of DNC by families [21].

In addition, the determination of BD/DNC plays a significant role in organ donation. The declaration of BD/DNC is a separate medical diagnosis that should be made independently, not considering the needs for organ transplantation. The association of BD/DNC with organ donation processes demands rigorous ethical standards to ensure that decisions regarding brain death are made impartially, and with the utmost respect for the deceased and the family. This approach is crucial for maintaining trust in the medical system and ensuring that the integrity of both the diagnostic and transplant processes is upheld [4]. Unfortunately, the very process of diagnosing brain death involves certain risks. The apnea test, for instance, carries the potential to push a patient into full brain death due to the build-up of carbon dioxide and acidosis, a fact that raises ethical concerns as it could potentially induce the very condition it seeks to confirm [16].

Moreover, the ethical dilemma intensifies when considering the documented cases where individuals diagnosed with brain death, or undergoing procedures to confirm brain death, have later shown signs of recovery. These rare but significant instances challenge the finality and ethical acceptability of brain death determinations. It is crucial to recognize that death is considered irreversible, hence recovery from death is impossible. 'Reports of recovery' refer to cases where further observation and subsequent testing revealed that the initial diagnosis of irreversible brain function loss was a false positive. These cases emphasize the need for rigorous standards and the necessity for meticulous and accurate determination of brain death to avoid such false-positive determinations of brain death. If there is even the slight possibility of recovery, the moral justification for considering a patient dead and proceeding with organ harvesting becomes deeply contentious [15].

Legal issues. Various legal approaches have been implemented across jurisdictions to address issues related to death by neurological criteria and accommodate religious or cultural considerations. In Japan, death by neurologic criteria is only determined with prior consent, particularly in cases where organ donation is involved. In New Jersey, USA, death by neurologic criteria cannot be declared if there are indications that the patient would have objected, although in practice, this is typically not enforced if refusal is explicit [15]. In Illinois, USA, hospitals are required to adopt policies allowing healthcare personnel to consider a patient's religious views regarding the timing of death. In California, hospitals must establish protocols that permit a short postponement before ceasing cardiopulmonary support to accommodate religious or cultural practices. Similarly, in New York, hospitals must adopt policies that involve continued ventilation for a limited period if there are moral or religious objections to death by neurologic criteria. In Trinidad and Tobago, regulations stipulate that religious and cultural requests of the family must be accommodated as much as possible before and after ventilation removal, particularly in the context of organ donation [22]. In Israel, ventilation and related treatment must continue until cardiac arrest occurs if the patient contests DNC. Also in Israel, the patient's views must be taken into consideration before evaluating death by neurologic criteria, but clinicians generally refrain from proceeding if there is any objection.

What can be done to improve and unify criteria? To achieve unification of standards for BD/DNC determination, a comprehensive set of guidelines should be developed through international collaboration between such global organizations as the World Health Organization (WHO) or The American Academy of Neurology (AAN), involving the multidisciplinary input of neurologists, intensivists, ethicists, and legal experts. Regular review and updates of these guidelines are essential for incorporating the latest research and technological advancements [13]. Standardization of diagnostic criteria, including clinical and ancillary tests, should be implemented alongside uniform documentation practices. Training and certification programmes must be established to ensure the compliance of clinicians, and competent and accredited hospitals adhere to protocols. Support from legislation and regulatory frameworks is crucial for enforcing compliance [2], while public awareness

campaigns and transparent communication will ensure that patients and families understand the procedures and criteria used.

SUMMARY

Differences in protocols for determining brain death exist worldwide, and while efforts towards standardization are underway, certain aspects still require improvement. The endeavour to unify protocols worldwide faces challenges due to ethical and religious disparities. While the protocols serve an essential role in offering legal guidance to physicians, potentially mitigating legal liability, they will never absolve medical professionals of their ethical obligations. Physicians must always place the welfare of their patients at the forefront. They should have an unwavering conviction that the accepted brain death criteria are ethically justified and free from external pressures, including those related to organ transplantation.

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