

# Brain death: assessment of knowledge among final-year medical students

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## Abstract

Brain death, characterized by the total and irreversible cessation of cerebral functions, still generates doubts and discussions within the medical community. This descriptive study evaluated the knowledge of medical students regarding the brain death protocol, based on Federal Council of Medicine Resolution 2,173/2017. Medical interns participated by answering a specific questionnaire. The majority recognized the concept of brain death, but only 20.4% considered themselves capable of diagnosing it. Only 20.7% correctly identified the prerequisites and initial steps of the protocol, and only 13.2% correctly identified the required interval between the two clinical evaluations. The data reveal a significant gap in student training regarding the criteria and procedures related to brain death. It is concluded that strengthening education on this subject in medical schools is essential to contribute to greater diagnostic safety, reduction of family suffering, and an increase in organ donation.

**Keywords:** Brain death. Diagnosis. Knowledge. Students, medical.

## Resumo

### Morte encefálica: avaliação do conhecimento de alunos concluintes de medicina

Morte encefálica, caracterizada por parada total e irreversível das funções cerebrais, ainda gera dúvidas e discussões no meio médico. Este estudo descritivo avaliou o conhecimento de estudantes de medicina sobre o protocolo de morte encefálica, com base na Resolução do Conselho Federal de Medicina 2.173/2017. Participaram acadêmicos do internato médico, que responderam a um questionário específico. A maioria reconheceu o conceito de morte encefálica, mas apenas 20,4% se consideraram aptos a diagnosticá-la. Somente 20,7% identificaram corretamente os pré-requisitos e as condutas iniciais do protocolo, e apenas 13,2% acertaram o intervalo exigido entre as duas avaliações clínicas. Os dados evidenciam significativa lacuna na formação dos estudantes quanto aos critérios e procedimentos relacionados a morte encefálica. Conclui-se que é essencial fortalecer o ensino sobre o tema nos cursos de medicina, a fim de contribuir para maior segurança diagnóstica, redução do sofrimento familiar e aumento da doação de órgãos.

**Palavras-chave:** Morte encefálica. Diagnóstico. Conhecimento. Estudantes de medicina.

## Resumen

### Muerte encefálica: evaluación del conocimiento de estudiantes de medicina de último año

La muerte encefálica, caracterizada por el cese total e irreversible de las funciones cerebrales, aún genera dudas y discusiones en el ámbito médico. Este estudio descriptivo evaluó el conocimiento de estudiantes de medicina sobre el protocolo de muerte encefálica, basado en la Resolución del Consejo Federal de Medicina 2.173/2017. Participaron académicos del internado médico, quienes respondieron a un cuestionario específico. La mayoría reconoció el concepto de muerte encefálica, pero solo el 20,4% se consideró apto para diagnosticarla. Solo el 20,7% identificó correctamente los prerequisites y las conductas iniciais del protocolo, y solo el 13,2% acertó el intervalo exigido entre las dos evaluaciones clínicas. Los datos evidencian una laguna significativa en la formación de los estudiantes en cuanto a los criterios y procedimientos relacionados con la muerte encefálica. Se concluye que es esencial fortalecer la enseñanza sobre el tema en las facultades de medicina, con el fin de contribuir a una mayor seguridad diagnóstica, la reducción del sufrimiento familiar y el aumento de la donación de órganos.

**Palabras-clave:** Muerte encefálica. Diagnóstico. Conocimiento. Estudiantes de medicina.

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The concept of death has been discussed and transformed over time, so that death is no longer recognized only when an individual progresses to cardiac arrest, but also when there is loss of activity in the brainstem and the cerebral cortex due to known and irreversible causes, which characterizes brain death (BD)<sup>1,2</sup>. Brain death was first described in 1959 by the researchers Pierre Mollaret and Maurice Goullon<sup>3</sup> after they identified clinical and pathological findings in a group of patients who presented deep coma, absence of respiration and an electroencephalogram with an isoelectric pattern<sup>4</sup>.

The definition of BD is well established, both scientifically and in ethical and moral terms, as the unquestionable manifestation of an individual's death, although ventilation and the maintenance of tissue perfusion may still be present through artificial means<sup>5</sup>. For this reason, suspecting that a patient may be in BD, confirming this diagnosis and properly managing the case are essential not only to improve the allocation of organs for transplantation but also to avoid the artificial maintenance of life in patients who are already dead<sup>6</sup>.

Patients in BD are potential organ donors, and for this to occur in practice, physicians must be able to confirm this diagnosis based on the criteria established by the Brazilian Federal Council of Medicine (CFM) in Resolution 2,173/2017<sup>7</sup>. However, significant differences can be observed between the criteria adopted in different countries, especially regarding the number of clinical examinations, the intervals between them, the requirement for complementary tests, the preferred type of ancillary examination to be performed, and the qualifications of the physician responsible for conducting the examinations<sup>5,8</sup>.

Delayed recognition of BD may lead to hemodynamic instability, the use of unnecessary interventions, increased family distress and a high rate of refusal of organ donation, thereby hindering the completion of transplants. In 2018, in Brazil, approximately 4,000 patients who met the criteria for BD were not identified and therefore went unreported as potential donors. In 2019, due to a 5.2% increase in the identification of potential donors with BD, the notification rate rose to 54.7 individuals per million inhabitants per year<sup>8</sup>.

Brain death must be determined and recorded by the medical team according to the criteria

defined by the CFM. An accurate diagnosis has implications for the exercise of professional ethics, requiring medical teams to understand the concept of BD and be able to identify and manage it in accordance with the applicable legal regulations. Although the concept of BD is well defined in legislation, physicians may still have questions regarding the diagnosis of BD and the maintenance of potential donors<sup>4</sup>.

In light of the above, the present study is of great importance, as it aims to assess the knowledge of future physicians about BD, as well as its implications for organ donation.

## Method

This is a prospective, analytical, descriptive, cross-sectional study conducted with medical internship students from a medical school in the central region of the state of Rio Grande do Sul between January and July 2024. A total of 170 students were enrolled in the program.

After signing an informed consent form, students were asked to respond voluntarily and anonymously to a questionnaire designed to assess their understanding of the diagnostic criteria for BD. A self-administered questionnaire created in Google Forms was distributed to all students via instant messaging applications, institutional email and in person. The sample size was determined through a calculation for finite populations, allowing for a 5% margin of error with a 95% confidence level, resulting in a random sample of at least 53 students, according to the inclusion criteria (students enrolled in the medical internship during the first semester of 2024 and affiliated with the institution).

The questionnaire consisted of two stages: the first addressed sociodemographic characteristics and educational background; the second assessed technical and ethical knowledge contained in CFM Resolution 2,173/2017<sup>7</sup>, which establishes the criteria for the determination of brain death in Brazil. The questionnaire was adapted from Bitencourt and collaborators<sup>6</sup> in accordance with the guidelines of the aforementioned CFM resolution.

All completed questionnaires submitted by students who met the inclusion criteria and agreed to participate by signing the informed consent form were analyzed. In the study, qualitative variables were analyzed using the chi-square test or Fisher's exact test. Associations were considered significant when  $p < 0.05$ . The software IBM SPSS, version 25, was used for statistical analysis of the data. It should be noted that some questions were optional, which may explain the variation in the total number of responses.

## Results

Of the 170 students enrolled in the medical internship between January and July 2024, 83.5% (n=142) agreed to participate in this study. The sample consisted of 90 (63.4%) female students and 51 (35.9%) male students, while one participant did not identify their gender. Regarding the distribution by semester of the program, the highest concentration was observed in the tenth semester (n=43; 30.3%), followed by the eleventh (n=38; 26.8%), twelfth (n=34; 23.9%) and ninth (n=27; 19%). More than half of the participants identified as Catholic (n=76; 53.5%), while Evangelicals and Spiritists represented the same proportion (n=15 each; 10.6%). Additionally, 6.3%

(n=9) declared themselves atheists and 19% (n=27) reported other religious beliefs.

When asked whether they had ever attended a class on brain death (BD), either during their undergraduate studies or at an event such as a conference, 77.5% (n=110) responded that they had. Meanwhile, 93% (n=132) reported that the topic had not been sufficiently addressed during the course, and 48.6% (n=69) stated that they felt capable of explaining what BD is to a patient's family member. However, only 20.4% (n=29) considered themselves capable of diagnosing a patient with BD.

Regarding the questionnaire on technical and ethical knowledge, the overall mean score of correct answers was 4.6 out of 10. The mean scores by semester—ninth, tenth, eleventh and twelfth—were 4.2, 4.3, 5.1 and 4.7 correct answers, respectively.

Most students (85.9%; n=122) correctly identified the concept of BD as the complete and irreversible loss of brain function with the inability to sustain life without artificial support. However, 63.4% (n=90) failed to correctly identify the criteria for BD in Brazil.

Table 1 presents the percentages of the remaining responses regarding knowledge of diagnostic criteria, complementary tests and signs used to determine BD.

**Table 1.** Knowledge of diagnostic criteria, complementary tests and signs for the determination of brain death

Which brain functions must be absent for a person to be declared brain dead?	n	(%)
Irreversible loss of cortical function	18	13.0
Irreversible loss of all cortical and brainstem functions*	78	58.5
Variable according to the law and country	23	16.7
I do not know	19	13.8
The following are complementary tests that may be performed to confirm brain death, EXCEPT:	n	(%)
Cerebral arteriography	16	11.4
Electroencephalogram	10	7.2
Cranial computed tomography*	87	62.1
Transcranial Doppler	27	19.3
Which of the following is NOT a physical examination test used in the evaluation of a patient with suspected brain death?	n	(%)
Pupillary light reflex	6	4.3
Corneal reflex	12	8.8
Cough reflex	51	37.2
Fixed pupils unreactive to light	9	6.6
Babinski sign*	59	43.1

\* Correct answer

Regarding decision-making in the event of suspected brain death (BD), only 31% (n=44) recognized notifying the attending physician as the appropriate initial action in this process. Furthermore, 82.4% (n=117) of the students correctly indicated that the diagnosis of BD requires two clinical evaluations performed by different qualified physicians, with a time interval between them, in addition to the apnea test and a complementary examination.

With regard to the appropriate moment to inform the family about the possibility of BD, 21.1% (n=30) correctly indicated that this should occur at the beginning of the protocol. Other participants indicated later moments, such as after the first clinical examination (21.6%; n=30), after the completion of complementary tests

(23.7%; n=33) or after evaluation by a neurologist (19.4%; n=27). Regarding the time interval between the two clinical evaluations in patients older than 24 months, only 13.2% (n=18) of the participants correctly identified the minimum interval of one hour. This was the question with the highest number of incorrect responses in the questionnaire—12 hours: 33.8% (n=46); 6 hours: 28.7% (n=39); and 24 hours: 24.3% (n=33).

Table 2 presents a comparative analysis of the performance of students who reported having attended a class on BD and those who had not participated in such an activity. Although a higher absolute number of correct answers was observed among students who had attended the class in the evaluated questions, no statistically significant differences were found.

**Table 2.** Comparative analysis of correct answers between students who attended and those who did not attend a class on brain death

Questions	Attended a class on BD				p <sup>*</sup>
	YES		NO		
	n	(%)	n	(%)	
What is the concept of brain death?	93	(84.5%)	29	(90.6%)	0.384
To initiate the brain death protocol, the following prerequisites must be considered, except:	27	(24.5%)	9	(28.1%)	0.682
What is the interval between the two clinical evaluations in a patient older than 24 months?	11	(10.0%)	7	(21.9%)	0.075
Which brain functions must be absent for a person to be declared brain dead?	62	(56.4%)	16	(50.0%)	0.524
What actions should be taken at the beginning of the brain death protocol?	34	(30.9%)	10	(31.3%)	0.971
At what point should the family be informed of the possibility of brain death?	24	(21.8%)	6	(18.8%)	0.708

\* Chi-square test

Table 3 presents a comparison of the performance between students who consider themselves capable of diagnosing brain death (BD) and those who do not feel prepared to do so. No statistically significant differences were observed between the groups in almost

all questions, except for the one addressing the brain functions that must be absent for the declaration of BD. In this case, students who considered themselves capable showed significantly better performance (72.4% versus 50.4%; p=0.034).

**Table 3.** Comparison of performance on correctly answered questions between students who consider themselves capable and those who do not consider themselves capable of diagnosing brain death

Questions	Consider themselves capable				p <sup>*</sup>
	YES		NO		
	n	(%)	n	(%)	
What is the concept of brain death?	22	(75.9%)	100	(88.5%)	0.081
The following are criteria for brain death in Brazil, except:	10	(34.5%)	42	(37.2%)	0.789
The following are complementary tests that may be performed to confirm brain death, except:	18	(62.1%)	69	(61.1%)	0.921
To initiate the brain death protocol, the following prerequisites must be considered, except:	6	(20.7%)	30	(26.5%)	0.518
Which of the following is not a physical examination test used in the evaluation of a patient with suspected brain death?	13	(44.8%)	46	(40.7%)	0.688
What is the interval between the two clinical evaluations in a patient older than 24 months?	2	(6.9%)	16	(14.2%)	0.294
Which brain functions must be absent for a person to be declared brain dead?	21	(72.4%)	57	(50.4%)	0.034

\* Chi-square test

## Discussion

The study had a high participation rate compared with other studies published in the literature involving medical students. Most participants identified as female, a result similar to those reported in previous studies<sup>6,8</sup>.

Most students correctly identified the concept of brain death (BD) and 77.5% (n=110) reported that the topic had been addressed at some point during medical school. However, when asked whether the instruction had been sufficient, only 7% (n=10) responded affirmatively. The lack of a solid theoretical foundation is evident in the finding that approximately 80% of students did not consider themselves capable of diagnosing a patient with brain death. A similar result was found in a study conducted in the state of Santa Catarina<sup>8</sup>, in which 84.2% of the students did not feel capable of diagnosing BD. In view of this, more effective and continuous education on BD is

necessary in order to ensure accurate diagnosis, greater confidence in medical decision-making and increased preparedness among future physicians.

The mean score on the questionnaire among medical students in the final years of the course was 46%. This low performance reveals insufficient knowledge regarding the concept and diagnosis of BD, as previously demonstrated by other authors. Bitencourt and collaborators<sup>6</sup> identified an average of 6.7 correct answers out of 14 in their study, corresponding to 47.8%. More recently, Nardoto<sup>9</sup> assessed knowledge of BD among 80 students in the final two years of medical school at a university in the state of Sergipe and found that, on a scale from 0 to 10, most students scored 4, indicating limited knowledge of the topic<sup>6,9</sup>.

Most students (74.6%) demonstrated a lack of knowledge regarding the prerequisites for diagnosing BD, as they did not correctly identify that these criteria include the presence of brain injury of known and irreversible cause, the absence

of potentially treatable factors and the requirement for observation in a hospital environment for at least six hours. The CFM emphasizes that uncertainty regarding the irreversibility of the injury or its cause prevents the determination of BD and, consequently, any organ donation process.

Complementary examinations play a key role in confirming the diagnosis of BD, as they demonstrate the absence of brain activity and the lack of cerebral blood perfusion. For this reason, they constitute a mandatory step in the Brazilian protocol for determining BD. Most students (62.1%) correctly answered the question about the tests indicated to confirm brain death and recognized that computed tomography is not an appropriate test for this diagnosis. This result is positive when compared with findings from the Santa Catarina study<sup>8</sup>, where 29.7% of students incorrectly indicated cranial computed tomography as part of the protocol.

When asked about the required time interval between the two clinical evaluations, 86.8% of participants were unable to correctly identify the one-hour interval, making this the most incorrectly answered question. Although this is a highly specific question, detailed knowledge of the time intervals described in the protocol established by the CFM resolution is essential, as they are crucial for the timely confirmation of BD and the organ donation process.

The comparative analysis between students who had and had not attended classes on BD revealed no statistically significant differences in the percentage of correct answers related to the concept of BD, clinical evaluations, absent brain functions and the initial procedures of the protocol. This may reflect an insufficient methodological approach during the course, a phenomenon also observed by Bitencourt and collaborators<sup>6</sup>, who reported limited exposure of medical students to intensive care practice during their undergraduate training.

CFM Resolution 2,173/2017<sup>7</sup> introduced the possibility of BD confirmation by specialists other than neurologists. One of the physicians conducting the examination must be trained in at least one of the following specialties: neurology, neurosurgery, neuropediatrics, intensive care medicine or emergency medicine, while the other

must have at least two years of experience with BD protocols. This change appears to be well established, as 84.3% of participants correctly identified the need for two different physicians and the fact that one of them does not necessarily have to be a neurologist.

As demonstrated in previous studies, the transmission of knowledge about BD in medical schools remains insufficient, which may have adverse implications for the clinical practice of future physicians and for society. The results of this study corroborate previous research highlighting the need to improve teaching on BD in medical schools, particularly in training students to perform accurate and safe diagnoses in their professional practice<sup>6,8,9,10</sup>. One of the earliest studies addressing this issue dates back to 2007, and an analysis of subsequent developments shows that, nearly twenty years later, medical schools still face considerable challenges in teaching about BD.

Although Brazil is among the three countries with the highest number of organ transplants in the world, with 28,533 organs transplanted in 2023, including bone marrow and corneas, this number could be significantly higher<sup>11</sup>. The Tatiane Law<sup>12</sup>, enacted in 2023, represented progress in raising awareness and improving the organ donation process by establishing stricter guidelines for identifying potential donors and ensuring that the diagnosis of BD is performed accurately and ethically. However, the lack of knowledge among many physicians regarding the criteria and protocols related to BD remains a significant obstacle, preventing the proper identification of donors and, consequently, the performance of transplants. It is estimated that 60% of brain death cases in Brazil go unreported, with the main causes of underdiagnosis being lack of technical resources, insufficient medical information and inadequate family preparation for dealing with death<sup>13</sup>.

## Final considerations

The results of this study show that most medical students enrolled in the internship who responded to the questionnaire recognize the theoretical concept of brain death (BD). Most reported that the topic had been addressed


at some point during the course, but not to a sufficient extent. A large proportion of them do not feel capable of diagnosing a patient with brain death. However, even among those who consider themselves capable, most are unfamiliar with the criteria, prerequisites and the time interval required between medical evaluations.

Therefore, a review of medical school curricula is needed to expand knowledge about the diagnosis and protocol for BD, so that more people may benefit from organ donation and reduced suffering. Further studies are necessary to evaluate, among medical students, other aspects related to the recognition and diagnosis of brain death.

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#### Contribution of the authors

Gisandra de Fátima Stangherlin participated in the study conception and design, coordination of data collection, data analysis and interpretation, manuscript writing and approval of the final version. Heloísa Chiarini participated in the data collection and organization, data analysis, participation in manuscript writing, critical review of intellectual content and approval of the final version. Luiza de Gregori Dutra participated in the data collection, systematization of information, participation in data analysis, initial drafting of the manuscript and approval of the final version. Natalia Alini Haubenthal participated in the data analysis and interpretation, methodological support, writing and critical revision of the manuscript and approval of the final version. Clandio Marques participated in the study conception, methodological guidance, critical analysis of the results, final revision of the manuscript and approval of the final version. Liliani Brum participated in the data collection, database organization, support in data analysis, critical revision of the manuscript and approval of the final version. Juliana Silveira participated in the participation in data collection and interpretation, manuscript writing, critical review of intellectual content and approval of the final version. Kelly de Oliveira Harada and study supervision, contribution to data analysis and interpretation, final revision of the manuscript and approval of the final version.

**Data availability:** All data used or generated in the research are fully described and presented in the body of the article.

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