

BÖLÜM 2

ERİŞKİNLERDE BEYİN ÖLÜMÜ TANISI

Mustafa Kemal ŞAHİN¹

GİRİŞ

Beyin ölümüne sebep olan beyin hasarları intrakraniyal ya da ekstrakraniyal olayların bir sonucu olarak meydana gelir. İskemik ya da hemorajik beyin hasarı beyin ölümü ile sonuçlanabilir. Beyin ölümüne neden olan ana ekstrakraniyal olay, bir kardiyopulmoner arrest sonrası, gecikmiş veya yetersiz bir resüsitasyonun beyinin ihtiyacı olan kan desteğini sağlayamamasıdır. Bunu takip eden hipoksi ve iskemi hücreSEL ozmoregülasyonu bozar, beyin parankim hücrelerinin içérisine giren su miktarı artar ve beyin ödemine sebebiyet verir. Beyin dokusunun içinde bulunduğu hacmin sabit olması nedeni ile, parankimde artan ödem ve şişme global olarak bir dolaşım bozukluğuna yol açarak sağlam kalan beyin dokusunun da hipoksik kalmasına ve ödemlenmesine yol açar. Beyin bu süreğelen ödeminin zararlı sonucu, aşırı derece artan bir intrakraniyal basınç ve bu basınçla birlikte beyin dokusunun aşırı sıkışıp aseptik nekrozuna neden olmaktadır, hatta daha da artan basınçlar kan dolaşımını imkansız hale getiren herniasyona sebebiyet verir (1).

¹ Uzm Dr, Siirt Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon AD,
mksahin@msn.com

KAYNAKLAR

1. Machado C. Diagnosis of brain death. Neurology International [Internet]. 2010 [cited 2022 Jan 20];2(1):7–13. Available from: [/pmc/articles/PMC3093212/](https://pmc.ncbi.nlm.nih.gov/articles/PMC3093212/)
2. Wahlster S, Wijdicks EFM, Patel P V., Greer DM, Hemphill JC, Carone M, et al. Brain death declaration: Practices and perceptions worldwide. Neurology [Internet]. 2015 May 5 [cited 2022 Jan 20];84(18):1870–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/25854866/>
3. Society N, Extraction T, Transplantation T, Legislation S. Turkish Neurological Society Diagnostic Guidelines for Brain Death *. 2014;101–4.
4. Burkle CM, Schipper AM, Wijdicks EFM. Brain death and the courts. Neurology [Internet]. 2011 Mar 1 [cited 2022 Jan 21];76(9):837–41. Available from: <https://pubmed.ncbi.nlm.nih.gov/21357836/>
5. Rosenberg JH, Alter M, Byrne TN, Daube JR, Franklin G, Frishberg B, et al. Practice parameters for determining brain death in adults (summary statement). The Quality Standards Subcommittee of the American Academy of Neurology. Neurology [Internet]. 1995 [cited 2022 Jan 21];45(5):1012–4. Available from: <https://pubmed.ncbi.nlm.nih.gov/7746374/>
6. Wijdicks EFM, Varelas PN, Gronseth GS, Greer DM. Evidence-based guideline update: determining brain death in adults: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology [Internet]. 2010 Jun 8 [cited 2022 Jan 21];74(23):1911–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/20530327/>
7. Braksick SA, Robinson CP, Gronseth GS, Hocker S, Wijdicks EFM, Rabinstein AA. Variability in reported physician practices for brain death determination. Neurology [Internet]. 2019 Feb 26 [cited 2022 Jan 21];92(9):E888–94. Available from: <https://pubmed.ncbi.nlm.nih.gov/30804063/>
8. Mathur M, Petersen L, Stadtler M, Rose C, Ejike JC, Petersen F, et al. Variability in pediatric brain death determination and documentation in southern California. Pediatrics [Internet]. 2008 May [cited 2022 Jan 21];121(5):988–93. Available from: <https://pubmed.ncbi.nlm.nih.gov/18450904/>

9. Shappell CN, Frank JI, Husari K, Sanchez M, Goldenberg F, Ardel A. Practice variability in brain death determination: a call to action. *Neurology [Internet]*. 2013 Dec 3 [cited 2022 Jan 21];81(23):2009–14. Available from: <https://pubmed.ncbi.nlm.nih.gov/24198290/>
10. Goudreau JL, Wijdicks EFM, Emery SF. Complications during apnea testing in the determination of brain death: predisposing factors. *Neurology [Internet]*. 2000 Oct 10 [cited 2022 Jan 21];55(7):1045–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/11061269/>
11. Wijdicks EFM, Rabenstein AA, Manno EM, Atkinson JD. Pronouncing brain death: Contemporary practice and safety of the apnea test. *Neurology [Internet]*. 2008 Oct 14 [cited 2022 Jan 21];71(16):1240–4. Available from: <https://pubmed.ncbi.nlm.nih.gov/18852438/>
12. Shemie SD, Langevin S, Farrell C. Therapeutic hypothermia after cardiac arrest: another confounding factor in brain-death testing. *Pediatric neurology [Internet]*. 2010 [cited 2022 Jan 21];42(4):304. Available from: <https://pubmed.ncbi.nlm.nih.gov/20304340/>
13. Saposnik G, Bueri JA, Mauriño J, Saizar R, Garretto NS. Spontaneous and reflex movements in brain death. *Neurology [Internet]*. 2000 Jan 11 [cited 2022 Jan 21];54(1):221–3. Available from: <https://pubmed.ncbi.nlm.nih.gov/10636153/>
14. Saposnik G, Maurino J, Saizar R, Bueri JA. Spontaneous and reflex movements in 107 patients with brain death. *The American journal of medicine [Internet]*. 2005 [cited 2022 Jan 21];118(3):311–4. Available from: <https://pubmed.ncbi.nlm.nih.gov/15745731/>
15. Beckmann YY, Çiftçi Y, Seçil Y, Eren S. Fasciculations in brain death. *Critical care medicine [Internet]*. 2010 [cited 2022 Jan 21];38(12):2377–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/20890193/>
16. Lévesque S, Lessard MR, Nicole PC, Langevin S, LeBlanc F, Lauzier F, et al. Efficacy of a T-piece system and a continuous positive airway pressure system for apnea testing in the diagnosis of brain death. *Critical care medicine [Internet]*. 2006 Aug [cited 2022 Jan 21];34(8):2213–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/16540953/>
17. Datar S, Fugate J, Rabinstein A, Couillard P, Wijdicks EFM. Completing the apnea test: decline in complications. *Neurocritical care [Internet]*. 2014 Dec 1 [cited 2022 Jan 21];21(3):392–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/24522760/>

18. Sharpe MD, Young GB, Harris C. The apnea test for brain death determination: an alternative approach. *Neurocritical care* [Internet]. 2004 [cited 2022 Jan 21];1(3):363–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/16174935/>
19. Wijdicks EFM, Manno EM, Holets SR. Ventilator self-cycling may falsely suggest patient effort during brain death determination. *Neurology* [Internet]. 2005 Sep 13 [cited 2022 Jan 21];65(5):774. Available from: <https://pubmed.ncbi.nlm.nih.gov/16157923/>
20. McGee WT, Mailloux P. Ventilator autocycling and delayed recognition of brain death. *Neurocritical care* [Internet]. 2011 Apr [cited 2022 Jan 22];14(2):267–71. Available from: <https://pubmed.ncbi.nlm.nih.gov/21222050/>
21. Shah V, Lazaridis C. Apnea testing on extracorporeal membrane oxygenation: Case report and literature review. *Journal of critical care* [Internet]. 2015 Aug 1 [cited 2022 Jan 21];30(4):784–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/25891646/>
22. Pirat A, Kömürcü Ö, Yener G et al. Apnea testing for diagnosing brain death during ext- racorporeal membrane oxygenation. 2014;28(1):e8-e9.
23. Wijdicks EFM. Brain death worldwide: accepted fact but no global consensus in diagnostic criteria. *Neurology* [Internet]. 2002 Jan 8 [cited 2022 Jan 21];58(1):20–5. Available from: <https://pubmed.ncbi.nlm.nih.gov/11781400/>
24. Rossetti AO, Oddo M, Logroscino G, Kaplan PW. Prognostication after cardiac arrest and hypothermia: a prospective study. *Annals of neurology* [Internet]. 2010 Mar [cited 2022 Jan 21];67(3):301–7. Available from: <https://pubmed.ncbi.nlm.nih.gov/20373341/>
25. Lustbader D, O'Hara D, Wijdicks EFM, MacLean L, Tajik W, Ying A, et al. Second brain death examination may negatively affect organ donation. *Neurology* [Internet]. 2011 Jan 11 [cited 2022 Jan 22];76(2):119–24. Available from: <https://pubmed.ncbi.nlm.nih.gov/21172836/>
26. MacDougall BJ, Robinson JD, Kappus L, Sudikoff SN, Greer DM. Simulation-based training in brain death determination. *Neurocritical care* [Internet]. 2014 Dec 1 [cited 2022 Jan 21];21(3):383–91. Available from: <https://pubmed.ncbi.nlm.nih.gov/24692109/>
27. (PDF) Multisection Dynamic CT Perfusion for Acute Cerebral Ischemia: The “Toggling-table” Technique [Internet]. [cited 2022

- Jan 22]. Available from: https://www.researchgate.net/publication/11924150_Multisection_Dynamic_CT_Perfusion_for_Acute_Cerebral_Ischemia_The_%27%27Toggling-table%27%27_Technique
28. Spieth ME, Ansari AN, Kawada TK, Kimura RL, Siegel ME. Direct comparison of Tc-99m DTPA and Tc-99m HMPAO for evaluating brain death. Clinical nuclear medicine [Internet]. 1994 [cited 2022 Jan 22];19(10):867–72. Available from: <https://pubmed.ncbi.nlm.nih.gov/7805319/>
29. Duyn JH, Van Gelderen P, Talagala L, Koretsky A, De Zwart JA. Technological advances in MRI measurement of brain perfusion. Journal of magnetic resonance imaging : JMRI [Internet]. 2005 Dec [cited 2022 Jan 22];22(6):751–3. Available from: <https://pubmed.ncbi.nlm.nih.gov/16267852/>
30. Savard M, Turgeon AF, Gariépy JL, Trottier F, Langevin S. Selective 4 vessels angiography in brain death: a retrospective study. The Canadian journal of neurological sciences Le journal canadien des sciences neurologiques [Internet]. 2010 Jul 1 [cited 2022 Jan 22];37(4):492–7. Available from: <https://pubmed.ncbi.nlm.nih.gov/20724258/>
31. O'Donnell DC. Case courtesy of Dr Chris O'Donnell, Radiopaedia.org, rID: 16808.
32. Persistence of cerebral blood flow after brain death - PubMed [Internet]. [cited 2022 Jan 22]. Available from: <https://pubmed.ncbi.nlm.nih.gov/10798503/>
33. Kuo JR, Chen CF, Chio CC, Chang CH, Wang CC, Yang CM, et al. Time dependent validity in the diagnosis of brain death using transcranial Doppler sonography. Journal of neurology, neurosurgery, and psychiatry [Internet]. 2006 May [cited 2022 Jan 22];77(5):646–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/16614026/>
34. Ünal, Ali; Dora B. Beyin Ölümü Tanısında Destekleyici Bir Test Olarak Transkranital Doppler Ultrasonografisi. Turkish Journal of Cerebrovascular Diseases [Internet]. 2012;18(3):49–58. Available from: <http://ir.obihiro.ac.jp/dspace/handle/10322/3933>
35. Lampl Y, Gilad R, Eschel Y, Boaz M, Rapoport A, Sadeh M. Diagnosing brain death using the transcranial Doppler with a transorbital approach. Archives of neurology [Internet]. 2002 [cited 2022 Jan 22];59(1):58–60. Available from: <https://pubmed.ncbi.nlm.nih.gov/11790231/>

36. Thompson BB, Wendell LC, Potter NS, Fehnel C, Wilterdink J, Silver B, et al. The use of transcranial Doppler ultrasound in confirming brain death in the setting of skull defects and extraventricular drains. *Neurocritical care [Internet]*. 2014 Dec 1 [cited 2022 Jan 22];21(3):534–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/24718963/>
37. Cabrer C, Domínguez-Roldan JM, Manyalich M, Trias E, Paredes D, Navarro A, et al. Persistence of intracranial diastolic flow in transcranial Doppler sonography exploration of patients in brain death. *Transplantation proceedings [Internet]*. 2003 [cited 2022 Jan 22];35(5):1642–3. Available from: <https://pubmed.ncbi.nlm.nih.gov/12962741/>
38. Dosemeci L, Dora B, Yilmaz M, Cengiz MI, Balkan S, Ramazanoglu A. Utility of transcranial doppler ultrasonography for confirmatory diagnosis of brain death: two sides of the coin. *Transplantation [Internet]*. 2004 Jan 15 [cited 2022 Jan 22];77(1):71–5. Available from: <https://pubmed.ncbi.nlm.nih.gov/14724438/>
39. Kalia DS. Case courtesy of Dr Shekhar Kalia, Radiopaedia.org, rID: 30173.
40. Karantanas AH, Hadjigeorgiou GM, Paterakis K, Sfiras D, Komnos A. Contribution of MRI and MR angiography in early diagnosis of brain death. *European radiology [Internet]*. 2002 Nov 1 [cited 2022 Jan 22];12(11):2710–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/12386761/>
41. Welschehold S, Kerz T, Boor S, Reuland K, Thömke F, Reuland A, et al. Computed tomographic angiography as a useful adjunct in the diagnosis of brain death. *Journal of Trauma and Acute Care Surgery [Internet]*. 2013 May [cited 2022 Jan 22];74(5):1279–85. Available from: https://www.researchgate.net/publication/236266337_Computed_tomographic_angiography_as_a_useful_adjunct_in_the_diagnosis_of_brain_death
42. Karakuş K, Demirci S, Cengiz AY, Atalar MH. Confirming the brain death diagnosis using brain CT angiography: Experience in Tokat State Hospital. *International Journal of Clinical and Experimental Medicine*. 2014;7(7):1747–51.
43. Kramer AH, Roberts DJ. Computed tomography angiography in the diagnosis of brain death: a systematic review and meta-analysis. *Neurocritical care [Internet]*. 2014 Dec 1 [cited 2022 Jan 22];21(3):539–50. Available from: <https://pubmed.ncbi.nlm.nih.gov/24939056/>

44. Quesnel C, Fulgencio JP, Adrie C, Marro B, Payen L, Lembert N, et al. Limitations of computed tomographic angiography in the diagnosis of brain death. *Intensive care medicine* [Internet]. 2007 Dec [cited 2022 Jan 22];33(12):2129–35. Available from: <https://pubmed.ncbi.nlm.nih.gov/17643226/>
45. Garrett MP, Williamson RW, Bohl MA, Bird CR, Theodore N. Computed tomography angiography as a confirmatory test for the diagnosis of brain death. *Journal of neurosurgery* [Internet]. 2018 Feb 1 [cited 2022 Jan 22];128(2):639–44. Available from: <https://pubmed.ncbi.nlm.nih.gov/28304181/>
46. Wieler H, Marohl K, Kaiser KP, Klawki P, Frossler H. Tc-99m HM-PAO cerebral scintigraphy. A reliable, noninvasive method for determination of brain death. *Clinical nuclear medicine* [Internet]. 1993 [cited 2022 Jan 22];18(2):104–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/8432051/>
47. Bonetti MG, Ciritella P, Valle G, Perrone E. 99mTc HM-PAO brain perfusion SPECT in brain death. *Neuroradiology* [Internet]. 1995 Jul [cited 2022 Jan 22];37(5):365–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/7477835/>
48. Munari M, Zucchetta P, Carollo C, Gallo F, De Nardin M, Marzola MC, et al. Confirmatory tests in the diagnosis of brain death: comparison between SPECT and contrast angiography. *Critical care medicine* [Internet]. 2005 [cited 2022 Jan 22];33(9):2068–73. Available from: <https://pubmed.ncbi.nlm.nih.gov/16148482/>
49. De la Riva A, Gonzalez FM, Llamas-Elvira JM, Latre JM, Jimenez-Heffernan A, Vidal E, et al. Diagnosis of brain death: superiority of perfusion studies with 99Tcm-HMPAO over conventional radio-nuclide cerebral angiography. *The British journal of radiology* [Internet]. 1992 [cited 2022 Jan 22];65(772):289–94. Available from: <https://pubmed.ncbi.nlm.nih.gov/1581783/>
50. Guideline 3: Minimum technical standards for EEG recording in suspected cerebral death. *Journal of clinical neurophysiology : official publication of the American Electroencephalographic Society* [Internet]. 2006 Apr [cited 2022 Jan 22];23(2):97–104. Available from: <https://pubmed.ncbi.nlm.nih.gov/16612224/>
51. Report of special Task Force. Guidelines for the determination of brain death in children. *American Academy of Pediatrics Task Force*

- on Brain Death in Children - PubMed [Internet]. [cited 2022 Jan 22]. Available from: <https://pubmed.ncbi.nlm.nih.gov/3615102/>
52. Rothstein TL. Recovery from near death following cerebral anoxia: A case report demonstrating superiority of median somatosensory evoked potentials over EEG in predicting a favorable outcome after cardiopulmonary resuscitation. Resuscitation [Internet]. 2004 Mar [cited 2022 Jan 22];60(3):335–41. Available from: <https://pubmed.ncbi.nlm.nih.gov/15050767/>
53. Ashwal S, Schneider S. Failure of electroencephalography to diagnose brain death in comatose children. Annals of neurology [Internet]. 1979 [cited 2022 Jan 22];6(6):512–7. Available from: <https://pubmed.ncbi.nlm.nih.gov/394669/>
54. Auditory brain stem responses in the detection of brain death - PubMed [Internet]. [cited 2022 Jan 22]. Available from: <https://pubmed.ncbi.nlm.nih.gov/12529570/>
55. Facco E, Munari M, Gallo F, Volpin SM, Behr AU, Baratto F, et al. Role of short latency evoked potentials in the diagnosis of brain death. Clinical neurophysiology : official journal of the International Federation of Clinical Neurophysiology [Internet]. 2002 Nov [cited 2022 Jan 22];113(11):1855–66. Available from: <https://pubmed.ncbi.nlm.nih.gov/12417241/>
56. Experimental studies on effects of barbiturate on electroencephalogram and auditory brain-stem responses - PubMed [Internet]. [cited 2022 Jan 22]. Available from: <https://pubmed.ncbi.nlm.nih.gov/9436367/>
57. Guérat JM. Medical technology assessment EEG and evoked potentials in the intensive care unit. Neurophysiologie clinique = Clinical neurophysiology [Internet]. 1999 [cited 2022 Jan 22];29(4):301–17. Available from: <https://pubmed.ncbi.nlm.nih.gov/10546249/>
58. Hüttemann E, Schelenz C, Sakka SG, Reinhart K. Atropine test and circulatory arrest in the fossa posterior assessed by transcranial Doppler. Intensive care medicine [Internet]. 2000 [cited 2022 Jan 22];26(4):422–5. Available from: <https://pubmed.ncbi.nlm.nih.gov/10872134/>
59. Díaz-Regañón G, Miñambres E, Holanda M, González-Herrera S, López-Espadas F, Garrido-Díaz C. Usefulness of venous oxygen saturation in the jugular bulb for the diagnosis of brain death: report

- of 118 patients. Intensive care medicine [Internet]. 2002 [cited 2022 Jan 22];28(12):1724–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/12447514/>
60. The Diagnosis of Stupor and Coma - Fred Plum, Jerome B. Posner - Google Kitaplar [Internet]. [cited 2022 Jan 22]. Available from: https://books.google.com.tr/books?hl=tr&lr=&id=Pbl4CH4NIQsC&oi=fnd&pg=PA1&dq=Plum+F,+Posner+JB.+The+Diagnosis+of+Stupor+and+Coma.+Philadelphia:+Davis%3B+1966.&ots=GwE6f_G3gg&sig=5UEUtS9dvmqoywJN1jV_c3Kw90s&redir_esc=y#v=o-nepage&q=Plum F%2C Posner JB. The Diagnosis of Stupor and Coma. Philadelphia%3A Davis%3B 1966.&f=false
 61. Patterson JR, Grabois M. Locked-in syndrome: A review of 139 cases. Stroke. 1986;17(4):758–64.
 62. Mortality and complications of the locked-in syndrome - PubMed [Internet]. [cited 2022 Jan 22]. Available from: <https://pubmed.ncbi.nlm.nih.gov/2432852/>
 63. Bauer G, Gerstenbrand F, Rumpl E. Varieties of the locked-in syndrome. Journal of neurology [Internet]. 1979 Aug [cited 2022 Jan 22];221(2):77–91. Available from: <https://pubmed.ncbi.nlm.nih.gov/92545/>
 64. Smith E, Delargy M. Locked-in syndrome. BMJ (Clinical research ed) [Internet]. 2005 Feb 19 [cited 2022 Jan 22];330(7488):406–9. Available from: <https://pubmed.ncbi.nlm.nih.gov/15718541/>
 65. Martí-Massó JF, Suárez J, López de Munain A, Carrera N. Clinical signs of brain death simulated by Guillain-Barré syndrome. Journal of the neurological sciences [Internet]. 1993 Dec 1 [cited 2022 Jan 22];120(1):115–7. Available from: <https://pubmed.ncbi.nlm.nih.gov/8289072/>
 66. Hassan T, Mumford C. Guillain-Barré syndrome mistaken for brain stem death. Postgraduate Medical Journal [Internet]. 1991 [cited 2022 Jan 22];67(785):280. Available from: [/pmc/articles/PMC2399004/?report=abstract](https://pmc/articles/PMC2399004/?report=abstract)
 67. Induced hypothermia after cardiopulmonary resuscitation: possible adverse effects. Signa Vitae [Internet]. 2007 [cited 2022 Jan 22];2(1):15. Available from: https://www.researchgate.net/publication/26461960_Induced_hypothermia_after_cardiopulmonary_resuscitation_possible_adverse_effects

68. DF D, RS P. Accidental hypothermia. *The New England journal of medicine* [Internet]. 1994 [cited 2022 Jan 22];331(26):2579–82. Available from: <https://pubmed.ncbi.nlm.nih.gov/7984198/>
69. Gilbert M, Busund R, Skagseth A, Nilsen PÅ, Solbø JP. Resuscitation from accidental hypothermia of 13.7 degrees C with circulatory arrest. *Lancet (London, England)* [Internet]. 2000 Jan 29 [cited 2022 Jan 22];355(9201):375–6. Available from: <https://pubmed.ncbi.nlm.nih.gov/10665559/>
70. Grattan-Smith PJ, Butt W, Grattan-Smith PJ, Butt W. Suppression of brainstem reflexes in barbiturate coma. *Archives of Disease in Childhood* [Internet]. 1993 [cited 2022 Jan 22];69(1):151. Available from: [/pmc/articles/PMC1029434/?report=abstract](https://pmc/articles/PMC1029434/?report=abstract)
71. Yang KL, Dantzker DR. Reversible brain death. A manifestation of amitriptyline overdose. *Chest* [Internet]. 1991 [cited 2022 Jan 22];99(4):1037–8. Available from: <https://pubmed.ncbi.nlm.nih.gov/2009762/>
72. Stulin ID. The diagnosis of brain death. *The New England journal of medicine* [Internet]. 2001 [cited 2022 Jan 22];344(16):87. Available from: <https://pubmed.ncbi.nlm.nih.gov/11309637/>