

Bölüm 18

YOĞUN BAKIMDA TRANSKRANİYAL DOPPLER VE OPTİK SİNİR ULTRASONOGRAFİSİ

Büşra TOK ÇEKMECELİOĞLU¹

GİRİŞ

Rune Aaslid tarafından 1982 yılında geliştirilmiş olan Transkraniyal Doppler (TKD), serebral hemodinamikin eş zamanlı analizi için temel teknik haline gelmiş ve nöromonitörizasyonun önde gelen araçlarından biri olmuştur⁽¹⁾. TKD; serebral kan akım hızı, spektral dalga formları, kan akım yönü ve bazal intrakraniyal arterlerin yoğunluğunun değerlendirilmesi için kullanılan; non-invaziv, maliyet etkin, taşınabilir ve güvenilir bir ultrasonografi tekniğidir. TKD modern tıpta: “kraniyal steteskop” olarak adlandırılmıştır.

Transkraniyal doppler, serebral hemodinamiklerin ve embolizasyonun uzun periyotlarda kesintisiz olarak değerlendirilmesini sağlayarak doğrudan bilgi sunan tek yöntemdir ve pek çok farklı alanda kullanılır (Tablo1)⁽²⁾. Bununla birlikte, perioperatif dönemde ve yoğun bakımlarda TKD kullanımı hala yaygınlık kazanamamış ve klinisyenlerin bu alandaki bilgi ve tecrübeleri eksik kalmıştır. Bu bölümde; temel TKD prensipleri, uygulanması ve yoğun bakımda TKD kullanımı anlatılarak güncel bilgilerin paylaşılmaktadır.

¹ Postdoctoral Research Fellow, Houston Methodist Hospital, Houston/ABD, tokbusra@gmail.com

SONUÇ

Transkraniyal doppler ve optik sinir ultrasonografisinin yoğun bakım ünitelerinde kullanımı giderek yaygınlaşmaktadır. Non-invaziv oluşu, ucuz, güvenli ve yatak başı uygulanabilirliği ile TKD yeri doldurulamaz bir serebrovasküler monitör olmuştur. Teknolojinin hızla gelişimi sayesinde TKD kullanım alanları ve stratejilerinin gelişimi mutlaklıdır. Ancak halen yoğun bakımı eğitiminde standart bir TKD eğitim yeterliliği ve öğrenme eğrisi tanımlanmamıştır. Yakın gelecekte yeterliliğe dayalı bir müfredat belirlenmesi TKD'ın doğru ve etkin kullanımını arttıracaktır.

KAYNAKLAR

1. Aaslid R, Markwalder TM, Nornes H. Noninvasive transcranial Doppler ultrasound recording of flow velocity in basal cerebral arteries. *J Neurosurg.* 1982;57(6):769-774. doi:10.3171/jns.1982.57.6.0769
2. Hacke, W. (2011). *Cerebrovascular ultrasound in stroke prevention and treatment.* John Wiley & Sons.
3. Moehring MA, Spencer MP. Power M-mode transcranial Doppler ultrasound and simultaneous single gate spectrogram. *Ultrasound Med Biol* 2002;28:49-57.
4. Valdeuza JM, Balzer JO, Villringer A, et al. Changes in blood flow velocity and diameter of the middle cerebral artery during hyperventilation: assessment with MR and transcranial Doppler sonography. *AJNR Am J Neuroradiol* 1997;18:1929-34.
5. Aaslid R. (2012). *Transcranial doppler sonography.* Springer Science & Business Media.
6. Perktold K, Karner G. Computational principles and models of hemodynamics. In: *Cerebrovascular Ultrasound-Theory, Practice and Future Developments, Part I: Ultrasound Physics, Technology and Hemodynamics* 2001 Oct 25 (pp. 63-76). Cambridge University Press.
7. Otis SM, Ringelstein EB. (1996). The transcranial Doppler examination: principles and applications of transcranial Doppler sonography. In: Tegeler CH, Babikian VL, Gomez CR. *Neurosonology.* pp 140-155.
8. Hennerici M, Rautenberg W, Sitzer G, et al. Transcranial Doppler ultrasound for the assessment of intracranial arterial flow velocity-Part 1. Examination technique and normal values. *Surg Neurol* 1987;27:439-448.
9. Giller CA, Lam M, Roseland A. Periodic variations in transcranial Doppler mean velocities. *J Neuroimaging* 1993; 3: 160-2
10. Garami Z, Alexandrov AV. Neurosonology. *Neurol Clin.* 2009;27(1):89-viii. doi:10.1016/j.ncl.2008.09.010
11. Tsigoulis G, Neumyer MM, Alexandrov AV. Diagnostic criteria for cerebrovascular ultrasound. *Cerebrovascular Ultrasound in Stroke Prevention and Treatment.* 2011 Feb 11:85-143.

12. Alexandrov AV, Molina CA, Grotta JC, et al. Ultrasound-enhanced systemic thrombolysis for acute ischemic stroke. *N Engl J Med.* 2004;351(21):2170-2178. doi:10.1056/NEJMoa041175
13. Ringelstein EB, Droste DW, Babikian VL, et al. Consensus on microembolus detection by TCD. International Consensus Group on Microembolus Detection. *Stroke.* 1998;29(3):725-729. doi:10.1161/01.str.29.3.725
14. Russell D, Madden KP, Clark WM, Sandset PM, Zivin JA. Detection of arterial emboli using Doppler ultrasound in rabbits. *Stroke.* 1991;22(2):253-258. doi:10.1161/01.str.22.2.253
15. Georgiadis D, Siebler M. (2006). Detection of microembolic signals with transcranial Doppler ultrasound. In *Handbook on Neurovascular Ultrasound (Vol. 21, pp. 194-205)*. Karger Publishers.
16. International Cerebral Hemodynamics Society. The International Cerebral Hemodynamics Society Consensus Statement. *Stroke* 1995;26:1123.
17. Garami ZF, Bismuth J, Charlton-Ouw KM, et al. Feasibility of simultaneous pre- and postfilter transcranial Doppler monitoring during carotid artery stenting. *J Vasc Surg.* 2009;49(2):340-345. doi:10.1016/j.jvs.2008.08.102
18. Robba C, Cardim D, Sekhon M, et al. Transcranial Doppler: a stethoscope for the brain-neurocritical care use. *J Neurosci Res.* 2018;96(4):720-730. doi:10.1002/jnr.24148
19. Ract C, Le Moigno S, Bruder N, et al. Transcranial Doppler ultrasound goal-directed therapy for the early management of severe traumatic brain injury. *Intensive Care Med.* 2007;33(4):645-651. doi:10.1007/s00134-007-0558-6
20. Robba C, Cardim D, Tajsic T, et al. Ultrasound non-invasive measurement of intracranial pressure in neurointensive care: A prospective observational study. *PLoS Med.* 2017;14(7):e1002356. Published 2017 Jul 25. doi:10.1371/journal.pmed.1002356
21. Bellner J, Romner B, Reinstrup P, et al. Transcranial Doppler sonography pulsatility index (PI) reflects intracranial pressure (ICP). *Surg Neurol.* 2004;62(1):45-51. doi:10.1016/j.surneu.2003.12.007
22. Rosenfeld JV, Maas AI, Bragge P, et al. Early management of severe traumatic brain injury. *Lancet.* 2012;380(9847):1088-1098. doi:10.1016/S0140-6736(12)60864-2
23. Klingelhöfer J, Conrad B, Benecke R, et al. Intracranial flow patterns at increasing intracranial pressure. *Klin Wochenschr.* 1987;65(12):542-545. doi:10.1007/BF01727619
24. Homburg AM, Jakobsen M, Enevoldsen E. Transcranial Doppler recordings in raised intracranial pressure. *Acta Neurol Scand.* 1993;87(6):488-493. doi:10.1111/j.1600-0404.1993.tb04142.x
25. Tsvigoulis G, Alexandrov AV, Sloan MA. Advances in transcranial Doppler ultrasonography. *Curr Neurol Neurosci Rep.* 2009;9(1):46-54. doi:10.1007/s11910-009-0008-7
26. Lau VI, Arntfield RT. Point-of-care transcranial Doppler by intensivists. *Crit Ultrasound J.* 2017;9(1):21. Published 2017 Oct 13. doi:10.1186/s13089-017-0077-9
27. Consensus Group on Transcranial Doppler in Diagnosis of Brain Death. Latin American consensus on the use of transcranial Doppler in the diagnosis of brain death. *Rev Bras Ter Intensiva.* 2014;26(3):240-252. doi:10.5935/0103-507x.20140035

28. Orban JC, El-Mahjoub A, Rami L, et al. Transcranial Doppler shortens the time between clinical brain death and angiographic confirmation: a randomized trial. *Transplantation*. 2012;94(6):585-588. doi:10.1097/TP.0b013e3182612947
29. Volz KR. (2018). *Intracranial Cerebral Evaluation*. Diagnostic Ultrasound, Philadelphia, USA: Elsevier, 983-1005.
30. Escudero D, Otero J, Quindos B, et al. Transcranial Doppler ultrasound in the diagnosis of brain death. Is it useful or does it delay the diagnosis? *Med Intensiva* 2015; 39: 244-50.
31. Ducrocq X, Braun M, Debouverie M, et al. Brain death and transcranial Doppler: experience in 130 cases of brain dead patients. *J Neurol Sci* 1998; 160: 41-46. DOI: 10.1016/S0022-510X(98)00188-9]
32. Sloan MA, Alexandrov AV, Tegeler CH, et al. Assessment: transcranial Doppler ultrasonography: report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. *Neurology*. 2004;62(9):1468-1481. doi:10.1212/wnl.62.9.1468
33. Chang JJ, Tsivgoulis G, Katsanos AH, Malkoff MD, Alexandrov AV. Diagnostic Accuracy of Transcranial Doppler for Brain Death Confirmation: Systematic Review and Meta-Analysis. *AJNR Am J Neuroradiol*. 2016;37(3):408-414. doi:10.3174/ajnr.A4548
34. Kassell NF, Boarini DJ. Patients with ruptured aneurysm: Pre- and postoperative management. In: Wilkins RA (ed) *Cerebral arterial spasm*. Williams and Wilkins, Baltimore London. 1985.
35. Ljunggren B, Brandt L. The outcome in 100 consecutive cases of early aneurysm surgery. *Acta Neurochir (Wien)*. 1982;63(1-4):215-219. doi:10.1007/BF01728875
36. White H, Venkatesh B. Applications of transcranial Doppler in the ICU: a review. *Intensive Care Med*. 2006;32(7):981-994. doi:10.1007/s00134-006-0173-y
37. Weir B. The incidence and onset of vasospasm after subarachnoid hemorrhage from ruptured aneurysm. In: Wilkins RH (ed) *Cerebral arterial spasm*. Williams and Wilkins, Baltimore London. 1980. pp 302-5.
38. Lindegaard KF, Nornes H, Bakke SJ, et al. Cerebral vasospasm after subarachnoid haemorrhage investigated by means of transcranial Doppler ultrasound. *Acta Neurochir Suppl (Wien)*. 1988;42:81-84. doi:10.1007/978-3-7091-8975-7_16
39. Garami Z, Uchino K, Song J, et al. Reversed Flow in Basilar Artery with Occlusion Signs of Vertebral Artery and Basilar Artery on Power M Mode Doppler - Case Report. *J Neuroimaging* 2003;13(2):178.
40. Wong KS, Huang YN, Gao S, Lam WW, Chan YL, Kay R. Intracranial stenosis in Chinese patients with acute stroke. *Neurology*. 1998;50(3):812-813. doi:10.1212/wnl.50.3.812
41. Donnelly J, Aries MJ, Czosnyka M. Further understanding of cerebral autoregulation at the bedside: possible implications for future therapy. *Expert Rev Neurother*. 2015;15(2):169-185. doi:10.1586/14737175.2015.996552
42. Adams RJ, McKie VC, Hsu L, et al. Prevention of a first stroke by transfusions in children with sickle cell anemia and abnormal results on transcranial Doppler ultrasonography. *N Engl J Med*. 1998;339(1):5-11. doi:10.1056/NEJM199807023390102

43. Karvellas CJ, Fix OK, Battenhouse H, et al. Outcomes and complications of intracranial pressure monitoring in acute liver failure: a retrospective cohort study. *Crit Care Med.* 2014;42(5):1157-1167. doi:10.1097/CCM.0000000000000144
44. Nang KD, Reardon M, Lumsden A et al. Transcranial Doppler-Guided Resuscitation during Transcatheter Aortic Valve Replacement, *Journal of Cardiovascular Emergencies*, 2018 Mar 1;4(1):41-6.
45. Cardim D, Griesdale DE, Ainslie PN, et al. A comparison of non-invasive versus invasive measures of intracranial pressure in hypoxic ischaemic brain injury after cardiac arrest. *Resuscitation.* 2019;137:221-228. doi:10.1016/j.resuscitation.2019.01.002
46. Hakimi R, Alexandrov AV, Garami Z. Neuro-ultrasonography. *Neurol Clin.* 2020;38(1):215-229. doi:10.1016/j.ncl.2019.09.006
47. Ackerstaff RG, Suttorp MJ, van den Berg JC, et al. Prediction of early cerebral outcome by transcranial Doppler monitoring in carotid bifurcation angioplasty and stenting. *J Vasc Surg.* 2005;41(4):618-624. doi:10.1016/j.jvs.2005.01.034
48. Sinha, K., Legeza, P., Tekula, P. Autonomous Perioperative Transcranial Doppler Monitoring, 2020 Vascular Annual Meeting, July 2020, Virtual, e236.
49. Liao CC, Chen YF, Xiao F. Brain Midline Shift Measurement and Its Automation: A Review of Techniques and Algorithms. *Int J Biomed Imaging.* 2018;2018:4303161. doi:10.1155/2018/4303161
50. Geeraerts T, Launey Y, Martin L, et al. Ultrasonography of the optic nerve sheath may be useful for detecting raised intracranial pressure after severe brain injury. *Intensive Care Med.* 2007;33(10):1704-1711. doi:10.1007/s00134-007-0797-6
51. Sahu S, Swain A. Optic nerve sheath diameter: a novel way to monitor the brain. *Journal of Neuroanaesthesiology and Critical Care.* 2017 Feb;4(04):S13-8.
52. Le A, Hoehn ME, Smith ME, et al. Bedside sonographic measurement of optic nerve sheath diameter as a predictor of increased intracranial pressure in children. *Ann Emerg Med.* 2009;53(6):785-791. doi:10.1016/j.annemergmed.2008.11.025
53. Geeraerts T, Duranteau J, Benhamou D. Ocular sonography in patients with raised intracranial pressure: the papilloedema revisited. *Crit Care.* 2008;12(3):150. doi:10.1186/cc6893
54. Rajajee V, Vanaman M, Fletcher JJ, et al. Optic nerve ultrasound for the detection of raised intracranial pressure. *Neurocrit Care.* 2011;15(3):506-515. doi:10.1007/s12028-011-9606-8
55. Moretti R, Pizzi B, Cassini F, Vivaldi N. Reliability of optic nerve ultrasound for the evaluation of patients with spontaneous intracranial hemorrhage. *Neurocrit Care.* 2009;11(3):406-410. doi:10.1007/s12028-009-9250-8
56. Hansen HC, Lagrèze W, Krueger O, Helmke K. Dependence of the optic nerve sheath diameter on acutely applied subarachnoidal pressure - an experimental ultrasound study. *Acta Ophthalmol.* 2011;89(6):e528-e532. doi:10.1111/j.1755-3768.2011.02159.x

