

12.

BÖLÜM

KAFA TRAVMALARI

Adiye ÖZGÜVEN¹

GİRİŞ

Kafa travması; direk veya indirek etkilerle ortaya çıkabilen, klinik ciddiyetini travmayı oluşturan primer kuvvetlerin yanı sıra sekonder sistemik bozulmaların da etkilediği bir travma şeklidir.(1)Kısa süreli hücre sel iyon değışikliklerinden kaynaklanabilen geçici bir kafa karışıklığından, koma ile sonuçlanabilecek kalıcı yapısal bozukluklara kadar geniş bir klinik yelpazede görülen beyin fonksiyon bozukluğuna neden olabilmektedir.(2) Travmatik beyin hasarı (TBH) olarak bilinen bu durum, mortalitesi ve morbiditesi oldukça yüksek olan, önemli bir halk sağlığı sorunudur.(3) ABD’de her yıl TBH sonucu gelişen ,geçici veya kalıcı sakatlıklar nedeniyle yaklaşık olarak 80-90 bin kişi rehabilitasyona ihtiyaç duymaktadır.(1) Acil servise başvuran her dört travma hastasından birinde kafa travması görülmektedir.(3) TBH 4 yaş altında,15-24 yaş aralığında ve 75 yaş üstünde daha sık görülmektedir.(4) Erkeklerde daha fazla meydana gelmektedir. (5) ABD son verilerine göre, her yıl yaklaşık olarak 1,7 milyon kişinin kafa travması geçirdiği, 275 bin kişinin hastanede yatarak tedavi edildiği ve 52 bin kişinin öldüğü tahmin edilmektedir.(3)

Kafa travmasının önde gelen nedenleri ileri yaşlarda ve çocuklarda düşmeler (%43.7), genç ve erişkinlerde motorlu araç kazalarıdır(%21.5).

(3) Çocuklarda istismar yaygın bir nedendir.(6) 12 aydan küçük her 2000 bebekten birinde istismar sonucunda kafa travması gelişmektedir. (7) Irak ve Afganistan’daki savaşlardaki ,patlama etkisiyle gelişen TBH, ‘imza yaralanmaları’,askeri personelde %10-20’nde görüldüğü tahmin edilmektedir.(8-10) TBH; klinik durumun ciddiyetine göre ve Glasgow Koma Skalası (GKS) kullanılarak; hafif (GKS 13-15), orta(GKS 9-12) ve ciddi (GKS 3-8) olarak sınıflandırılır. Hafif TBH %75, orta TBH %15 ve ciddi TBH %10 görülmektedir. (1) Hafif TBH uzun dönemde kalıcı sekillere yol açabilmektedir.(11,12)

Travmaya bağlı hastane öncesinde gerçekleşen ölümlerin yaklaşık olarak %90 ında ciddi TBH bulunmaktadır.(1) TBH’ nın neden olduğu nörolojik sonuçlar ve prognoz, primer (travmanın etkisi) ve sekonder (sistemik bozulmalar; hipotansiyon, hipoksi gibi) hasarların boyutuna bağlıdır. Özellikle multiple travması olan kafa travmalı hastalarda tedavi, hastane öncesinde başlatılarak, sekonder sistemik bozulmalar önlenmektedir. Başlangıç GKS skoru, sistolik kan basıncı ve solunum sayısının kaydedilmesi, varsa bilinç kaybı süresinin ve posttravmatik amnezinin (PTA) belirtilmesi önemlidir.(13)Hastane öncesinde TBH tespit edilen hastalar, hızlıca bilgisayarlı tomografi (BT) ve beyin cerrahisi imkanı olan bir hastaneye nakledilmelidirler.

¹ Uzm. Dr., İzmir Ekonomi Üniversitesi Medicalpark Hastanesi, Acil Tıp Kliniği, adiye32@hotmail.com

lerin bulunmaması birçok araştırmacının kabul ettiği beyin ölümü kriterleridir. Elektroensefalografide aktivite yoktur. SKA yoktur. Çocuklarda ciddi TBH sonrası iyileşme daha fazla oranda görüldüğü için, beyin ölümü tanısı koyarken dikkatli olunmalıdır.(1)

SONUÇ

TBH ve sonrasındaki komplikasyonlar kalıcı sakatlıklar ve ölüme neden olabilen önemli bir halk sağlığı sorunudur.(3) GKS ile kafa travmasının ciddiyeti belirlenmeli gereklilik halinde BT taraması yapılmalı ve beyin cerrahisi konsültasyonu vakit kaybetmeden sağlanmalıdır. Tüm penetran, orta veya ciddi TBH olan hastalarda BT taraması yapılmalıdır.(1) Hastalar tekrarlayan bilinç ve nörolojik durum değerlendirilmeleriyle takip edilmeli, herniasyon bulgularına karşı uyanık olunmalıdır.Hafif TBH olan hastalara risk değerlendirilmesi yapılarak uygun görülen hastalara BT taraması yapılmalıdır. Antikoagülan kullanılan hastalardaki takip süreleri uzatılmalı ve INR seviyeleri normalize edilmelidir. Hipoksi ve hipotansiyonun TBH mortalitesini arttırdığı unutulmamalıdır.(1) Hangi ciddiyette olursa olsun TBH ndaki akut dönem tedavi hedefi primer beyin hasarı ve sekonder hasarlanmaya neden olabilecek sistemik bozulmaların düzeltilmesi olmalıdır.(27)

KAYNAKLAR

- Advanced Trauma Life Support®Tenth Edition 2018
- Menon DK, Schwab K, Wright DW, Maas AI: Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil 91: 1637, 2010. [PMID: 21044706]
- Faul M, Xu L, Wald MM, Coronado VG: Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths, 2002-2006. Atlanta: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.
- Robertson CS: Management of cerebral perfusion pressure after traumatic brain injury. Anesthesiology 95: 1513, 2001. [PMID: 11748413]
- Coronado VG, Xu L, Basavaraju SV, et al: Surveillance for traumatic brain injury-related deaths—United States, 1997-2007. MMWR Surveill Summ 60: 1, 2011. [PMID: 21544045]
- Greenwald BD, Burnett DM, Miller MA: Congenital and acquired brain injury. 1. Brain injury: Epidemiology and pathophysiology. Arch Phys Med Rehabil 2003; 84:S3-S7.
- Leventhal JM, Martin KD, Asnes AG: Fractures and traumatic brain injuries: Abuse versus accidents in a U.S. database of hospitalized children. Pediatrics 2010; 126:e104-e115.
- Brenner LA, et al: Traumatic brain injury, posttraumatic stress disorder, and postconcussive symptom reporting among troops returning from Iraq. J Head Trauma Rehabil 2010; 25:307-312.
- Hoge CW, et al: Mild traumatic brain injury in U.S. Soldiers returning from Iraq. N Engl J Med 2008; 358:4534-4563.
- Jaffee MS, et al: Acute clinical care and care coordination for traumatic brain injury within Department of Defense. J Rehabil Res Dev 2009; 46:655-666.
- http://www.cdc.gov/ncipc/pub-res/TBI_in_US_04/00_preliminary.htm (Langlois JA, Rutland Brown W, Thomas KE: Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. CDC Publication: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2004.) Accessed February 2, 2014.
- Thurman D: The epidemiology and economics of head trauma, in Miller L (ed): Head Trauma: Basic, Preclinical, and Clinical Directions. New York: Wiley and Sons; 2001.
- Corrigan JD, Selassie AW, Orman JA. The epidemiology of traumatic brain injury. J Head Trauma Rehabil. 2010; 25:72-80
- Rockswold G: Head injury. In: Tintanelli J, ed. Emergency Medicine. New York: McGraw-Hill; 1996.
- Carpenter M: Gross anatomy of the brain. In: Carpenter MB, ed. Core Text of Neuroanatomy, 4th ed. Baltimore: Williams & Wilkins; 1991
- Lenzlinger P: Overview of basic mechanisms underlying neuropathological consequences of head trauma. In: Miller LP, Hayes RL, Newcomb JK, eds. Head Trauma: Basic, Preclinical, and Clinical Directions. New York: Wiley-Liss; 2001:4-5.
- Zwienenberg M, Muizellar J: Vascular aspects of severe head injury. In: Miller LP, Hayes RL, Newcomb JK, eds. Head Trauma: Basic, Preclinical, and Clinical Directions. New York: Wiley-Liss; 2001:303-326.
- Reivich M: Arterial Pco2 and cerebral hemodynamics. Am J Physiol 1964; 206:25-35.
- Brain Trauma Foundation, et al: Guidelines for the management of severe traumatic brain injury. XIV. Hyperventilation. J Neurotrauma 2007; 24(Suppl 1):S87-S90.
- Laffey JG, Kavanagh BP: Hypocapnia. N Engl J Med 2002; 347:43-53.
- Biros MH, Heegaard W: Prehospital and resuscitative care of the head-injured patient. Curr Opin Crit Care 2001; 7:444-449.
- Greenberg M: Handbook of Neurosurgery, 7th ed. New York: Thieme; 2010.
- Fodstad H, Kelly PJ, Buchfelder M: History of the Cushing reflex. Neurosurgery 2006; 59:1132-1137.

24. Wang HE, Peitzman AB, Cassidy LD, Adelson PD, Yeady DM: Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. *Ann Emerg Med* 2004; 44:439-450.
25. Graham D, Gennarelli T: Pathology of brain damage after head injury. In: Cooper P, Golfinos J, eds. *Head Injury*, 4th ed. New York: McGrawHill; 2000:133-154.
26. Marmarou A, et al: Predominance of cellular edema in traumatic brain swelling in patients with severe head injuries. *J Neurosurg* 2006; 104:720-730.
27. William G. Heegaard and Michelle H. Biros. *Head Injury*. Rosen's emergency medicine : concepts and clinical practice / editor-in-chief, John A. Marx; senior editor, Robert S. Hockberger, Ron M. Walls; editors, Michelle H. Biros [et al.].—8th ed.; chapter 41.
28. Gordon KE, Dooley JM, Fitzpatrick EA, Wren P, Wood EP: Concussion or mild traumatic brain injury: Parents appreciate the nuances of nosology. *Pediatr Neurol* 2010; 43:253-257.
29. Gordon KE: Pediatric minor traumatic brain injury. *Semin Pediatr Neurol* 2006; 13:243-255
30. Chesnut RM: Care of central nervous system injuries. *Surg Clin North Am* 2007; 87:119-156, vii.
31. Greve MW, Zink BJ: Pathophysiology of traumatic brain injury. *Mt Sinai J Med* 2009; 76:97-104.
32. Maas AI, Stocchetti N, Bullock R: Moderate and severe traumatic brain injury in adults. *Lancet Neurol* 2008; 7:728-741.
33. Bazarian JJ, Blyth B, Cimpello L: Bench to bedside: Evidence for brain injury after concussion—looking beyond the computed tomography scan. *Acad Emerg Med* 2006; 13:199-214.
34. Brain Trauma Foundation, et al: Guidelines for the management of severe traumatic brain injury. I. Blood pressure and oxygenation. *J Neurotrauma* 2007; 24(Suppl 1):S7-S13.
35. Monroe A: Observation on the Structure and Function of the Nervous System. Edinburgh: Creek and Johnson; 1783. 35. Hohl CM, et al: The effect of a bolus dose of etomidate on cortisol levels, mortality, and health services utilization: A systematic review. *Ann Emerg Med* 2010; 56:105-113
37. Kulstad EB, Kalimullah EA, Tekwani KL, Courtney DM: Etomidate as an induction agent in septic patients: Red flags or false alarms? *West J Emerg Med* 2010; 11:161-172.
38. Ching KY, Baum CR: Newer agents for rapid sequence intubation: Etomidate and rocuronium. *Pediatr Emerg Care* 2009; 25:200-210.
39. Elder GA, Cristian A: Blast-related mild traumatic brain injury: Mechanisms of injury and impact on clinical care. *Mt Sinai J Med* 2009; 76:111-118.
40. Wilbur K, Zed PJ: Is propofol an optimal agent for procedural sedation and rapid sequence intubation in the emergency department? *CJEM* 2001; 3:302-310
41. Sheedy J, Geffen G, Donnelly J, Faux S: Emergency department assessment of mild traumatic brain injury and prediction of postconcussion symptoms at one month post injury. *J Clin Exp Neuropsychol* 2006; 28:755-772.
42. Goldschlager T, Rosenfeld JV, Winter CD: 'Talk and die' patients presenting to a major trauma centre over a 10 year period: A critical review. *J Clin Neurosci* 2007; 14:618-624.
43. Haydel MJ, et al: Indications for computed tomography in patients with minor head injury. *N Engl J Med* 2000; 343:100-105.
44. McCrory P, et al: Consensus statement on concussion in sport: The 3rd International Conference on Concussion in Sport held in Zurich, November 2008. *J Athl Train* 2009; 44:434-448.
45. Wilde EA, et al: Diffusion tensor imaging of acute mild traumatic brain injury in adolescents. *Neurology* 2008; 70:948-955.
46. McCrory P, Johnston KM, Mohtadi NG, Meeuwisse W: Evidence-based review of sport-related concussion: Basic science. *Clin J Sport Med* 2001; 11:160-165.
47. Bazarian JJ, Beck C, Blyth B, von Ahsen N, Hasselblatt M: Impact of creatine kinase correction on the predictive value of S-100B after mild traumatic brain injury. *Restor Neurol Neurosci* 24: 163, 2006. [PMID: 16873971]
48. Begaz T, Kyriacou DN, Segal J, Bazarian JJ: Serum biochemical markers for post-concussion syndrome in patients with mild traumatic brain injury. *J Neurotrauma* 23: 1201, 2006. [PMID: 16928178]
49. King WJ, MacKay M, Sirnick A: Shaken baby syndrome in Canada: clinical characteristics and outcomes of hospital cases. *CMAJ* 168: 155, 2003. [PMID: 12538542]
50. Jagoda AS, Bazarian JJ, Bruns JJ Jr, et al: Clinical policy: neuroimaging and decisionmaking in adult mild traumatic brain injury in the acute setting. *Ann Emerg Med* 52: 714, 2008. [PMID: 19027497]
51. US Food and Drug Administration. Evaluation of automatic class III designation for Banyan BrainTrauma Indicator. 2018
52. Frankel M, Fan L, Yeatts SD, Jeromin A, Vos PE, Wagner AK, Wolf BJ, Pauls Q, Lunney M, Merck LH, et al. Association of Very Early Serum Levels of S100B, Glial Fibrillary Acidic Protein, Ubiquitin C-Terminal Hydrolase-L1, and Spectrin Breakdown Product with Outcome in ProTECT III. *J Neurotrauma*. 2019 10 15; 36(20):2863-71. [PubMed: 30794101]
53. Dadas A, Washington J, Diaz-Arrastia R, Janigro D. Biomarkers in traumatic brain injury (TBI): a review. *Neuropsychiatr Dis Treat*. 2018 11 8; 14:2989-3000. [PubMed: 30510421]
54. Bazarian JJ, Biberthaler P, Welch RD, Lewis LM, Barzo P, Bogner-Flatz V, Gunnar Broolinson P, Büki A, Chen JY, Christenson RH, et al. Serum GFAP and UCH-L1 for prediction of absence of intracranial injuries on head CT (ALERT-TBI): a multicentre observational study. *Lancet Neurol*. 2018; 17(9):782-9. [PubMed: 30054151]
55. Mahan MY, Thorpe M, Ahmadi A, Abdallah T, Casey H, Sturtevant D, Judge-Yoakam S, Hoover C, Rafter D, Miner J, et al. Glial Fibrillary Acidic Protein (GFAP) Outperforms S100 Calcium Binding Protein B (S100B) and Ubiquitin C-Terminal Hydrolase L1 (UCH-L1) as Predictor for Positive Computed Tomography of the

- Head in Trauma Subjects. *World Neurosurg.* 2019 81;128:e434–44. [PubMed: 31051301]
56. Marmarou A, et al: IMPACT database of traumatic brain injury: Design and description. *J Neurotrauma* 2007; 24:239-250.
 57. Stein SC, Georgoff P, Meghan S, Mizra K, Sonnad SS: 150 years of treating severe traumatic brain injury: A systematic review of progress in mortality. *J Neurotrauma* 2010; 27:1343-1353.
 58. Teasdale G, Jennett B: Assessment of coma and impaired consciousness. A practical scale. *Lancet* 1974; 2:81-84.
 59. Daele JJ, Goffart Y, Machiels S: Traumatic, iatrogenic, and spontaneous cerebrospinal fluid (CSF) leak: Endoscopic repair. *B-ENT* 2011; 7(Suppl17):47-60
 60. Al-Nakshabandi NA. The swirl sign. *Radiology* 2001; 218:433.
 61. Mascia L: Acute lung injury in patients with severe brain injury: A double hit model. *Neurocrit Care* 2009; 11:417-426.
 62. Farhat HI, Hood B, Ullock MR: A tangential gunshot wound to the head: Case report and review of the literature. *J Emerg Med* 2009; Dec 21. [Epub ahead of print]
 63. Simon BJ, Macdonald, Antonio, Belli. Head and Neck Trauma. In: David WL, King, editor. *ABC of Imaging in Trauma*: Blackwell Publishing 2010:4-10.
 64. Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, et al. Surgical management of acute subdural hematomas. *Neurosurgery* 2006; 58:S16-24.
 65. Dalfino JC, Boulos AS. Visualization of an actively bleeding cortical vessel into the subdural space by CT angiography. *Clin Neurol Neurosurg* 2010; 112:737-9.
 66. Lee KS, Bae WK, Bae HG, Doh JW, Yun IG. The computed tomographic attenuation and the age of subdural hematomas. *J Korean Med Sci* 1997; 12:353-9.
 67. Drew LB, Drew WE. The countercoup-coup phenomenon: a new understanding of the mechanism of closed head injury. *Neurocrit Care* 2004; 1:385-90.
 68. Agrawal A, Timothy J, Pandit L, Manju M: Post-traumatic epilepsy: An overview. *Clin Neurol Neurosurg* 2006; 108:433-439.
 69. Schievink WI: Spontaneous spinal cerebrospinal fluid leaks. *Cephalalgia* 2008; 28:1345-1356.
 70. Cheuret E, et al: Intracranial hypotension in a girl with Marfan syndrome: Case report and review of the literature. *Childs Nerv Syst* 2008; 24:509-513.
 71. Chan EK, Yan B, Ryan MM: Spontaneous intracranial hypotension in childhood: A case report and review of the literature. *J Child Neurol* 2011; 26:761-766.
 72. Adekoya N, Thurman DJ, White DD, Webb KW: Surveillance for traumatic brain injury deaths—United States, 1989–1998. *MMWR Surveill Summ* 2002; 51:1-14.
 73. Beaman V, Annett JL, Mercy JA, Kresnow M, Pollock DA: Lethality of firearm-related injuries in the United States population. *Ann Emerg Med* 2000; 35:258-266.
 74. Part 1: Guidelines for the management of penetrating brain injury. Introduction and methodology. *J Trauma* 2001; 51:S3-S6.
 75. Part 2: Prognosis in penetrating brain injury. *J Trauma* 2001; 51:S44-S86.
 76. Anglin D, Hutson HR, Luftman J, Qualls S, Moradzadeh D: Intracranial hemorrhage associated with tangential gunshot wounds to the head. *Acad Emerg Med* 1998; 5:672-678.
 77. Antibiotic prophylaxis for penetrating brain injury. *J Trauma* 2001; 51:S34-S40.
 78. Modica PA, Tempelhoff R: Intracranial pressure during induction of anaesthesia and tracheal intubation with etomidate-induced EEG burst suppression. *Can J Anaesth* 1992; 39:236-241.
 79. Mosier JM, Joshi R, Hypes C, Pacheco G, Valenzuela T, Sakles JC: The physiologically difficult airway. *West J Emerg Med* 2015; 16(7):1109-17.
 80. Baekgaard JS, Eskesen TG, Sillesen N, Rasmussen LS, Steinmetz J. Ketamine as a Rapid Sequence Induction Agent in the Trauma Population: A Systematic Review. *Anesth&Analgesia*, 2019; 128(3):504-10.
 81. Fakhry SM, et al: Prehospital rapid sequence intubation for head trauma: Conditions for a successful program. *J Trauma* 2006; 60:997-1001.
 82. Salhi B, Stettner E: In defense of the use of lidocaine in rapid sequence intubation. *Ann Emerg Med* 2007; 49:84-86.
 83. Vaillancourt C, Kapur AK: Opposition to the use of lidocaine in rapid sequence intubation. *Ann Emerg Med* 2007; 49:86-87.
 84. Yeung JK, Zed PJ: A review of etomidate for rapid sequence intubation in the emergency department. *CJEM* 2002; 4:194-198
 85. Green SM, Roback MG, Kennedy RM, Krauss B. Clinical practice guideline for emergency department ketamine dissociative sedation: 2011 update. *Annals of emergency medicine*, 2011; 57(5):449-61.
 86. BrainTraumaFoundation, et al: Guidelines for the management of severe traumatic brain injury. II. Hyperosmolar therapy. *J Neurotrauma* 2007; 24(Suppl 1):S14-S20
 87. Nelson JA: Local skull trephination before transfer is associated with favorable outcomes in cerebral herniation from epidural hematoma. *Acad Emerg Med* 2011; 18:78-85.
 88. Smith SW, et al: Emergency department skull trephination for epidural hematoma in patients who are awake but deteriorate rapidly. *J Emerg Med* 2010; 39:377-383.
 89. Effects of tranexamic acid on death, disability, vascular occlusive events and other morbidities in patients with acute traumatic brain injury (CRASH-3): a randomised, placebo-controlled trial. *Lancet* 2019; 394: 1713–23
 90. Fabio Silvio Taccone, Giuseppe Citerio, Nino Stocchetti. Is tranexamic acid going to CRASH the management of traumatic brain injury? *Intensive Care Med* (2020) 46:1261–1263
 91. Andrew I. R. Maas, Ewout W. Steyerberg, Giuseppe Citerio. Tranexamic acid in traumatic brain injury: systematic review and meta-analysis trumps a large clinical trial? *Intensive Care Med* (2021) 47:74–76
 92. Hanbing Chen, Fei Wu, Penglei Yang, Jun Shao, Qihong Chen, Ruiqiang Zheng. A meta-analysis of the effects of

- therapeutic hypothermia in adult patients with traumatic brain injury. Chen et al. *Critical Care* (2019) 23:396
93. Cohan, Caitlin M, Beattie, Genna Bowman, Jessica A, et al. Repeat computed tomography head scan is not indicated in trauma patients taking novel anticoagulation: 2020 A multicenter study. *The journal of trauma and acute care surgery*, 89(2): 2163-0755
 94. Zeeshan M, Jehan F, O'Keeffe T, Khan M, Zakaria ER, Hamidi M, Gries L, Kulvatunyou N, Joseph B. The novel oral anticoagulants (NOACs) have worse outcomes compared with warfarin in patients with intracranial hemorrhage after TBI. *J Trauma Acute Care Surg*. 2018;85(5):915-20.
 95. Chauny JM, Marquis M, Bernard F, Williamson D, Albert M, Laroche M, Daoust R. Risk of Delayed Intracranial Hemorrhage in Anticoagulated Patients with Mild Traumatic Brain Injury: Systematic Review and Meta-Analysis. *J Emerg Med*. 2016;51(5):519-28.
 96. Brain Trauma Foundation, et al: Guidelines for the management of severe traumatic brain injury. XIII. Antiepileptic prophylaxis. *J Neurotrauma* 2007; 24(Suppl 1):S83-S86.
 97. Mazzola CA, Adelson PD: Critical care management of head trauma in children. *Crit Care Med* 2002; 30:S393-S401.
 98. Chang BS, Lowenstein DH: Practice parameter: Antiepileptic drug prophylaxis in severe traumatic brain injury: Report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 2003; 60:10-16.
 99. Lapointe M: Basic principles of antimicrobial therapy of CNS infections. In: Cooper P, Golfinos J, eds. *Head Injury*, 4th ed. New York: McGrawHill; 2000:483.
 100. Brain Trauma Foundation, et al: Guidelines for the management of severe traumatic brain injury. IV. Infection prophylaxis. *J Neurotrauma* 2007; 24(Suppl 1):S26-S31.
 101. Stein SC, Chen XH, Sinson GP, Smith DH: Intravascular coagulation: A major secondary insult in nonfatal traumatic brain injury. *J Neurosurg* 2002; 97:1373-1377.
 102. Dudley RR, et al: Early venous thromboembolic event prophylaxis in traumatic brain injury with low-molecular-weight heparin: Risks and benefits. *J Neurotrauma* 2010; 27:2165-2172.
 103. Cushing H: The blood pressure reaction of acute cerebral compression illustrated by cases of intracranial hemorrhage. *Am J Med Sci* 1903; 125:1017-1044.
 104. Rogers FB, et al: Neurogenic pulmonary edema in fatal and nonfatal head injuries. *J Trauma* 1995; 39:860-868
 105. Szerlip NJ, Bholat O, McCunn MM, Aarabi B, Scalea TM: Extracorporeal life support as a treatment for neurogenic pulmonary edema and cardiac failure secondary to intractable intracranial hypertension: A case report and review of the literature. *J Trauma* 2009; 67:E69-E71
 106. Hanson W: Acute respiratory failure in neuroemergencies. In: Cruz J, ed. *Neurologic and Neurosurgical Emergencies*. Philadelphia: WB Saunders; 1998:28-29.
 107. Provencio J, Bleck T: Cardiovascular disorders related to neuroemergencies. In: Cruz J, ed. *Neurologic and Neurosurgical Emergencies*. Philadelphia: WB Saunders; 1998:39-50.
 108. www.radiopaedia.org