CHAPTER 257

Head Trauma

David W. Wright Lisa H. Merck

REFERENCES

- Menon DK, Schwab K, Wright DW, Maas AI: Position statement: definition of traumatic brain injury. Arch Phys Med Rehabil 91: 1637, 2010. [PMID: 21044706]
- Langlois JA, Rutland-Brown W, Thomas KE: Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. Bethesda, MD: Centers for Disease Control and Prevention. National Center for Injury Prevention and Control: 2004.
- Thurman D: The epidemiology and economics of head trauma, in Miller L (ed): Head Trauma: Basic, Preclinical, and Clinical Directions. New York, NY: Wiley; 2001.
- 4. Faul M, Xu L, Wald MM, Coronado VG: Traumatic brain injury in the United States: emergency department visits, hospitalizations, and deaths. Bethesda, MD: Centers for Disease Control and Prevention, National Center for Injury Prevention and Control; 2010.
- 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]
- Taylor CA, Bell JM, Breiding MJ, Xu L: Traumatic brain injury-related emergency department visits, hospitalizations, and deaths-United States, 2007 and 2013. MMWR Surveill Summ 66: 1, 2017. [PMID: 28301451]
- Warden D: Military TBI during the Iraq and Afghanistan wars. J Head Trauma Rehabil 21: 398, 2006. [PMID: 16983225]
- Rangel-Castilla L, Lara LR, Gopinath S, et al: Cerebral hemodynamic effects of acute hyperoxia and hyperventilation after severe traumatic brain injury. J Neurotrauma 27: 1853, 2010. [PMID: 20684672]
- Robertson CS: Management of cerebral perfusion pressure after traumatic brain injury. Anesthesiology 95: 1513, 2001. [PMID: 11748413]
- Semplicini A, Inverso G, Realdi A, et al: Blood pressure control has distinct effects on executive function, attention, memory and markers of cerebrovascular damage. *J Hum Hypertens* 25: 80, 2011. [PMID: 20237503]
- McIntosh TK, Smith DH, Meaney DF, et al: Neuropathological sequelae of traumatic brain injury: relationship to neurochemical and biomechanical mechanisms. *Lab Invest* 74: 315, 1996. [PMID: 8780153]
- 12. Goodman JC, Van M, Gopinath SP, Robertson CS: Pro-inflammatory and pro-apoptotic elements of the neuroinflammatory response are activated in traumatic brain injury. *Acta Neurochir Suppl* 102: 437, 2008. [PMID: 19388362]
- 13. https://www.facs.org/~/media/files/quality%20programs/trauma/tqip/traumatic%20 brain%20injury%20guidelines.ashx (Cryer HG, Manley GT, Adelson D, et al: ACS TQIP best practices in the management of traumatic brain injury: traumatic brain injury guidelines.) Accessed March 5, 2019.
- Chesnut RM, Marshall LF, Klauber MR, et al: The role of secondary brain injury in determining outcome from severe head injury. J Trauma 34: 216, 1993. [PMID: 8459458]
- Butcher I, Maas AI, Lu J, et al: Prognostic value of admission blood pressure in traumatic brain injury: results from the IMPACT study. J Neurotrauma 24: 294, 2007. [PMID: 17375994]
- Bershad EM, Farhadi S, Suri MF, et al: Coagulopathy and inhospital deaths in patients with acute subdural hematoma. J Neurosurg 109: 664, 2008. [PMID: 18826353]
- Berry C, Ley EJ, Bukur M, et al: Redefining hypotension in traumatic brain injury. *Injury* 43: 1833, 2012. [PMID: 21939970]
- Talving P, Karamanos E, Teixeira PG, et al: Intracranial pressure monitoring in severe head injury: compliance with Brain Trauma Foundation guidelines and effect on outcomes: a prospective study. J Neurosurg 119: 1248, 2013. [PMID: 23971954]
- Griesdale DE, Sekhon MS, Menon DK, et al: Hemoglobin area and time index above 90 g/L are associated with improved 6-month functional outcomes in patients with severe traumatic brain injury. *Neurocrit Care* 23: 78, 2015. [PMID: 25510896]
- Carney N, Totten AM, O'Reilly C, et al: Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition. Neurosurgery 80: 6, 2017. [PMID: 27654000]
- Steiner LA, Czosnyka M, Piechnik SK, et al: Continuous monitoring of cerebrovascular pressure reactivity allows determination of optimal cerebral perfusion pressure in patients with traumatic brain injury. Crit Care Med 30: 733, 2002. [PMID: 11940737]
- Bratton SL, Chestnut RM, Ghajar J, et al: Guidelines for the management of severe traumatic brain injury. I. Blood pressure and oxygenation. J Neurotrauma 24(Suppl 1): S7, 2007. [PMID: 17511549]
- Spaite DW, Hu C, Bobrow BJ, et al: Mortality and prehospital blood pressure in patients with major traumatic brain injury: implications for the hypotension threshold. *JAMA* Surg 152: 360, 2017. [PMID: 27926759]
- Manley G, Knudson MM, Morabito D, et al: Hypotension, hypoxia, and head injury: frequency, duration, and consequences. Arch Surg 136: 1118, 2001. [PMID: 11585502]
- Vink R, Head VA, Rogers PJ, McIntosh TK, Faden AI: Mitochondrial metabolism following traumatic brain injury in rats. J Neurotrauma 7: 21, 1990. [PMID: 2342116]
- Lifshitz J, Sullivan PG, Hovda DA, Wieloch T, McIntosh TK: Mitochondrial damage and dysfunction in traumatic brain injury. Mitochondrion 4: 705, 2004. [PMID: 16120426]
- Raghupathi R, Graham DI, McIntosh TK: Apoptosis after traumatic brain injury. J Neurotrauma 17: 927, 2000. [PMID: 11063058]
- Smith DH, Chen XH, Pierce JE, et al: Progressive atrophy and neuron death for one year following brain trauma in the rat. J Neurotrauma 14: 715, 1997. [PMID: 9383090]

- Marmarou A: A review of progress in understanding the pathophysiology and treatment of brain edema. Neurosurg Focus 22: E1, 2007. [PMID: 17613227]
- Papadopoulos MC, Krishna S, Verkman AS: Aquaporin water channels and brain edema. Mt Sinai J Med 69: 242, 2002. [PMID: 12357265]
- 31. Papadopoulos MC, Verkman AS: Aquaporin-4 and brain edema. *Pediatr Nephrol (Berlin, Germany)* 22: 778, 2007. [PMID: 17347837]
- 32. Healey C, Osler TM, Rogers FB, et al: Improving the Glasgow Coma Scale score: motor score alone is a better predictor. *J Trauma* 54: 671, 2003. [PMID: 12707528]
- 33. Gill M, Windemuth R, Steele R, et al: A comparison of the Glasgow Coma Scale score to simplified alternative scores for the prediction of traumatic brain injury outcomes. Ann Emerg Med 45: 37, 2005. [PMID: 15635308]
- Thompson DO, Hurtado TR, Liao MM, et al: Validation of the Simplified Motor Score in the out-of-hospital setting for the prediction of outcomes after traumatic brain injury. *Ann Emerg Med* 58: 417, 2011. [PMID: 21803448]
- Singh B, Murad MH, Prokop LJ, et al: Meta-analysis of Glasgow coma scale and simplified motor score in predicting traumatic brain injury outcomes. *Brain Inj* 27: 293, 2013. [PMID: 23252405]
- Stiell IG, Wells GA, Vandemheen K, et al: The Canadian CT Head Rule for patients with minor head injury. Lancet 357: 1391, 2001. [PMID: 11356436]
- Stein SC, Fabiri A, Servadei F, Glick HA: A critical comparison of clinical decision instruments for computed tomographic scanning in mild closed traumatic brain injury in adolescents and adults. *Ann Emerg Med* 53: 180, 2009. [PMID: 18339447]
- Smits M, Dippel DW, Steyerberg EW, et al: Predicting intracranial traumatic findings on computed tomography in patients with minor head injury: the CHIP prediction rule. Ann Intern Med 146: 397, 2007. [PMID: 17371884]
- Ibanez J, Arikan F, Pedraza S, et al: Reliability of clinical guidelines in the detection of patients at risk following mild head injury: results of a prospective study. J Neurosurg 100: 825, 2004. [PMID: 15137601]
- Fabbri A, Servadei F, Marchesini G, et al: Clinical performance of NICE recommendations versus NCWFNS proposal in patients with mild head injury. *J Neurotrauma* 22: 1419, 2005. [PMID: 16379580]
- Kothari RU, Brott T, Broderick JP, et al: The ABCs of measuring intracerebral hemorrhage volumes. Stroke 27: 1304, 1996. [PMID: 8711791]
- Haydel MJ, Preston CA, Mills TJ, Luber S, Blaudeau E, DeBlieux PM: Indications for computed tomography in patients with minor head injury. N Engl J Med 343: 100, 2000. [PMID: 10891517]
- 43. Nuño T, Denninghoff KR, Pauls Q, et al: Reply to: Prehospital intubation: further confounders in trial results. *Prehosp Emerg Care* 22: 537, 2018. [PMID:29338483]
- 44. Chesnut RM, Marshall SB, Piek J, Blunt BA, Klauber MR, Marshall LF: Early and late systemic hypotension as a frequent and fundamental source of cerebral ischemia following severe brain injury in the Traumatic Coma Data Bank. Acta Neurochir Suppl 59: 121, 1993. [PMID: 8310858]
- Marmarou A, Lu J, Butcher I, et al: Prognostic value of the Glasgow Coma Scale and pupil reactivity in traumatic brain injury assessed pre-hospital and on enrollment: an IMPACT analysis. J Neurotrauma 24: 270, 2007. [PMID: 17375991]
- 46. Robinson N, Clancy M: In patients with head injury undergoing rapid sequence intubation, does pretreatment with intravenous lignocaine/lidocaine lead to an improved neurological outcome? A review of the literature. Emerg Med J18: 453, 2001. [PMID: 11696494]
- 47. Berry C, Ley EJ, Bukur M, et al: Redefining hypotension in traumatic brain injury. *Injury* 43: 1833, 2012. [PMID: 21939970]
- Butcher I, Maas AI, Lu J, et al: Prognostic value of admission blood pressure in traumatic brain injury: results from the IMPACT study. J Neurotrauma 24: 294, 2007. [PMID: 17375994]
- Sekhon MS, McLean N, Henderson WR, Chittock DR, Griesdale DE: Association of hemoglobin concentration and mortality in critically ill patients with severe traumatic brain injury. Crit Care 16: R128, 2012. [PMID: 22817913]
- Wright DW, Yeatts SD, Silbergleit R, et al: Very early administration of progesterone for acute traumatic brain injury. N Engl J Med 371: 2457, 2014. [PMID: 25493974]
- Tasker RC: Intracranial pressure: influence of head-of-bed elevation, and beyond. Pediatr Crit Care Med 13: 116, 2012. [PMID: 22222657]
- Coester A, Neumann CR, Schmidt MI: Intensive insulin therapy in severe traumatic brain injury: a randomized trial. *J Trauma* 68: 904, 2010. [PMID: 20032790]
- 53. Silbergleit R, Lowenstein D, Durkalski V, Conwit R, Neurological Emergency Treatment Trials (NETT) Investigators: RAMPART (Rapid Anticonvulsant Medication Prior to Arrival Trial): a double-blind randomized clinical trial of the efficacy of intramuscular midazolam versus intravenous lorazepam in the prehospital treatment of status epilepticus by paramedics. *Epilepsia* 52(Suppl 8): 45, 2011. [PMID: 21967361]
- Edwards P, Arango M, Balica L, et al: Final results of MRC CRASH, a randomised placebo-controlled trial of intravenous corticosteroid in adults with head injuryoutcomes at 6 months. *Lancet* 365: 1957, 2005. [PMID: 15936423]
- 55. Smits M, Dippel DW, de Haan GG, et al: Minor head injury: guidelines for the use of CT: a multicenter validation study. *Radiology* 245: 831, 2007. [PMID: 17911536]
- Friedman JA, Ebersold MJ, Quast LM: Posttraumatic cerebrospinal fluid leakage. World J Surg 25: 1062, 2001. [PMID: 11571972]
- King WJ, MacKay M, Sirnick A, Canadian Shaken Baby Study Group: Shaken baby syndrome in Canada: clinical characteristics and outcomes of hospital cases. CMAJ 168: 155, 2003. [PMID: 12538542]
- Bergsneider M, Hovda DA, Lee SM, et al: Dissociation of cerebral glucose metabolism and level of consciousness during the period of metabolic depression following human traumatic brain injury. J Neurotrauma 17: 389, 2000. [PMID: 10833058]
- Giza CC, Hovda DA: The neurometabolic cascade of concussion. J Athl Train 36: 228, 2001. [PMID: 12937489]

- Hovda DA: Oxidative need and oxidative capacity following traumatic brain injury. Crit Care Med 35: 663, 2007. [PMID: 17251724]
- Bazarian JJ, Zhong J, Blyth B, et al: Diffusion tensor imaging detects clinically important axonal damage after mild traumatic brain injury: a pilot study. J Neurotrauma 24: 1447, 2007. [PMID: 17892407]
- Bigler ED, Bazarian JJ: Diffusion tensor imaging: a biomarker for mild traumatic brain injury? *Neurology* 74: 626, 2010. [PMID: 20107137]
- Rivers E, Nguyen B, Havstad S, et al: Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med 345: 1368, 2001. [PMID: 11794169]
- Sabharwal RK, Sanchetee PC, Sethi PK, Dhamija RM: Chronic traumatic encephalopathy in boxers. I Assoc Physicians India 35: 571, 1987. [PMID: 3693310]
- 65. Omalu BI, Hamilton RL, Kamboh MI, DeKosky ST, Bailes J: Chronic traumatic encephalopathy (CTE) in a National Football League player: case report and emerging medicolegal practice questions. J Forensic Nurs 6: 40, 2010. [PMID: 20201914]
- McKee AC, Stern RA, Nowinski CJ, et al: The spectrum of disease in chronic traumatic encephalopathy. *Brain* 136: 43, 2013. [PMID: 23208308]
- Guskiewicz KM, McCrea M, Marshall SW, et al: Cumulative effects associated with recurrent concussion in collegiate football players: the NCAA Concussion Study. *JAMA* 290: 2549, 2003. [PMID: 14625331]
- Iverson GL, Gaetz M, Lovell MR, Collins MW: Cumulative effects of concussion in amateur athletes. *Brain Inj* 18: 433, 2004. [PMID: 15195792]
- Guskiewicz KM, Marshall SW, Bailes J, et al: Association between recurrent concussion and late-life cognitive impairment in retired professional football players. *Neurosurgery* 57: 719, 2005. [PMID: 16239884]
- Guskiewicz KM, Marshall SW, Bailes J, et al: Recurrent concussion and risk of depression in retired professional football players. Med Sci Sports Exerc 39: 903, 2007. [PMID: 17545878]
- 71. Cantu RC: Second-impact syndrome. Clin Sports Med 17: 37, 1998. [PMID: 9475969]
- Echemendia RJ, Meeuwisse W, McCrory P, et al: The Sport Concussion Assessment Tool 5th Edition (SCAT5): background and rationale. Br J Sports Med 51: 848, 2017. [PMID: 28446453]
- Mucha A, Collins MW, Elbin RJ, et al: A Brief Vestibular/Ocular Motor Screening (VOMS) assessment to evaluate concussions: preliminary findings. Am J Sports Med 42: 2479, 2014. [PMID: 25106780]
- 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]
- 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]
- Papa L, Silvestri S, Brophy GM, et al: GFAP out-performs S100β in detecting traumatic intracranial lesions on computed tomography in trauma patients with mild traumatic brain injury and those with extracranial lesions. *J Neurotrauma* 31: 1815, 2014. [PMID: 24903744]

- 77. Papa L, Brophy GM, Welch RD, et al: Time course and diagnostic accuracy of glial and neuronal blood biomarkers GFAP and UCH-L1 in a large cohort of trauma patients with and without mild traumatic brain injury. JAMA Neurol 73: 551, 2016. [PMID: 27018834]
- 78. Welch RD, Ayaz SI, Lewis LM, et al: Ability of serum glial fibrillary acidic protein, ubiquitin C-terminal hydrolase-L1, and S100B to differentiate normal and abnormal head computed tomography findings in patients with suspected mild or moderate traumatic brain injury. J Neurotrauma 33: 203, 2016. [PMID: 26467555]
- 79. Wang KK, Yang Z, Zhu T, et al: An update on diagnostic and prognostic biomarkers for traumatic brain injury. *Expert Rev Mol Diagn* 18: 165, 2018. [PMID: 29338452]
- Hanley D, Prichep LS, Bazarian J, et al: Emergency department triage of traumatic head injury using a brain electrical activity biomarker: a multisite prospective observational validation trial. Acad Emerg Med 24: 617, 2017. [PMID: 28177169]
- Lovell M, Collins M, Bradley J: Return to play following sports-related concussion. Clin Sports Med 23: 421, 2004. [PMID: 15262380]
- Guskiewicz KM, Bruce SL, Cantu RC, et al: Research based recommendations on management of sport related concussion: summary of the National Athletic Trainers' Association position statement. Br J Sports Med 40: 6, 2006. [PMID: 16371484]
- Ingersoll CD: Long term effects of closed head injuries in sport. Sports Med 16: 342, 1993.
 [PMID: 8272689]
- Mittenberg W, Tremont G, Zielinski RE, Fichera S, Rayls KR: Cognitive-behavioral prevention of postconcussion syndrome. Arch Clin Neuropsychol 11: 139, 1996. [PMID: 14588914]
- Butler IJ: Postconcussion syndrome after mild traumatic brain injury in children and adolescents requires further detailed study. JAMA Neurol 70: 636, 2013. [PMID: 23529540]
- Collins MW, Lovell MR, Iverson GL, et al: Cumulative effects of concussion in high school athletes. Neurosurgery 51: 1175, 2002. [PMID: 12383362]
- McCrory P, Davis G, Makdissi M: Second impact syndrome or cerebral swelling after sporting head injury. Curr Sports Med Rep 11: 21, 2012. [PMID: 22236821]
- Weinstein E, Turner M, Kuzma BB, Feuer H: Second impact syndrome in football: new imaging and insights into a rare and devastating condition. J Neurosurg Pediatr 11: 331, 2013. [PMID: 23277914]
- 89. Cohen DB, Rinker C, Wilberger JE: Traumatic brain injury in anticoagulated patients. *J Trauma* 60: 553, 2006. [PMID: 16531853]
- Fabbri A, Servadei F, Marchesini G, Stein SC, Vandelli A: Predicting intracranial lesions by antiplatelet agents in subjects with mild head injury. J Neurol Neurosurg Psychiatry 81: 1275. 2010. [PMID: 20643657]
- Fabbri A, Servadei F, Marchesini G, et al: Antiplatelet therapy and the outcome of subjects with intracranial injury: the Italian SIMEU study. Crit Care 17: R53, 2013. [PMID: 23514619]