The Role of Surgical Intervention in Traumatic Brain Injury

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KEYWORDS

• Neurosurgery • Traumatic brain injury • Neurotrauma • Decompressive craniectomy
• Neuromonitoring

KEY POINTS

- The general consensus to optimize the care for severe TBI patients is management at specialized neurotrauma centers with neurosurgical and neurocritical care support and the use of guidelines-based standardized protocols.
- It is important to recognize the heterogeneity of TBI and that the “one-size-fits-all approach” may not always be appropriate for all TBI patients.
- Knowledge synthesis activities in neurotrauma are important to define future research agendas. Advances have influenced neurotrauma as it continues to mature into a distinct subspecialty of neurosurgery.

TRAUMATIC BRAIN INJURY EPIDEMIOLOGY AND CRANIAL SURGERY RATES

In the United States, there were 2.5 million emergency department (ED) visits, hospitalizations, and deaths attributed to traumatic brain injuries (TBI) in 2010 alone, either as an isolated injury or in combination with extracranial injuries.[1] Approximately 2% of those patients (>50,000) died, accounting for approximately 40% of all deaths from acute injuries in the United States.[1] The major causes of TBI-related hospitalizations were falls, assaults, and motor vehicle traffic incidents.[1,2] TBI also remains the most common cause of disability among people younger than 40. An estimated 3.2 million to 5.3 million persons in the United States are living with disabilities acquired from a TBI-related event.[3–5] Since 2007, the number of TBI-related ED visits has increased by 56%.[1] This increase did not apply to TBI-related hospitalizations and deaths. TBI-related crude mortality rates slightly decreased from 18.2 to 17.1 per 100,000 persons from 2007 to 2010.[1] Although the exact cause for this decrease has not been established, it is thought to follow a continued reduction in motor vehicle traffic incidents. In addition, advances in prehospital and neuro–intensive care in specialized trauma centers led to improved care quality and health outcomes for TBI patients.[6] A study conducted using the National Trauma Data Bank (NTDB) found that craniotomies were performed in 3.6% of all head-injured patients.[7] More than 95% of patients with head injuries in the NTDB received conservative/nonoperative management. However, the NTDB included patients with both mild and moderate head injuries, and the absolute number of

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emergency cranial surgical procedures has not been established firmly.[7] It remains important to track these rates to assess practice patterns, implementations of guidelines, and impact on patient outcome.[7–9]

INVASIVE BRAIN MONITORING

Monitoring of intracranial pressure (ICP), clinical neurologic examination, and computed tomography (CT) scanning are currently the primary methods to guide treatment of patients with TBI during neurointensive care.[10,11] Unconscious or unstable patients are often sedated, therefore, limiting the utility of clinical examinations. In these cases, ICP monitoring is traditionally used to guide management to maintain adequate cerebral perfusion and oxygenation and avoid secondary injuries.[11,12] The BEST TRIP study provided evidence that patients may be treated without ICP monitoring.[13] However, the Brain Trauma Foundation guidelines and a recent consensus conference held in Milan recommend ICP monitoring in salvageable severe TBI patients with abnormal CT finding (mass lesions, swelling, herniation, or compressed basal cisterns).[11,14]

Measurement of ICP can be done in several ways. Many consider intraventricular catheters as the gold standard method of ICP monitoring.[11] This method allows both measurement of ICP and the possibility to treat raised ICP via drainage of cerebrospinal fluid (CSF). Intraventricular catheters can be connected with fluid-coupled catheter to an external strain gauge or available with an integrated micro strain gauge or fiber-optic–tipped catheter. As with all intraventricular catheters, there is chance of drain-related infections that increase the longer a catheter is in place.[15–17] In addition, in a trauma setting it can be technically challenging to insert an intraventricular catheter in a patient with cerebral edema, midline shift, or small/compressed ventricles.[18]

Intraparenchymal ICP monitoring devices use fiber-optic catheters to measure the ICP without CSF diversion. Compared with intraventricular catheters, parenchymal monitors are a less-invasive alternative to measure ICP and carry a lower risk of infection and hemorrhage.[19–21] However, this method does not allow CSF drainage for therapeutic purposes. There are varying reports on the drift of parenchymal monitors, although this drift is not deemed a clinical concern.[11,22–24] Subdural, subarachnoid, and epidural monitors are also described and are currently considered less accurate than intraventricular or intraparenchymal devices.[11] In TBI cases with mass lesions, it has been known that ICP is not transmitted equally throughout the intracranial space. Studies suggest that expanding mass lesions are associated with ICP gradients, in particular, acute subdural hematomas.[25] Greater than 10–mm Hg differences have been described between hemispheres. Further research is needed to define the optimal ICP measurement location to guide ICP management for these cases.

Multimodality neuromonitoring, including ICP, partial pressure of oxygen, and cerebral microdialysis can provide a more comprehensive monitoring of the injured brain than ICP monitoring alone.[10,12,26] These methods allow individualized management of secondary cerebral insults targeting patient-specific pathophysiology. Current cranial access devices enable multiple catheters and sensors to be transmitted into the brain parenchyma, to allow for ICP, cerebral microdialysis (monitoring of chemistry of the extracellular space), and partial pressure of oxygen (monitoring of cerebral oxygen metabolism) catheters to be monitored continuously at the bed-side.[27]

EVACUATION OF INTRACRANIAL HEMATOMAS

The role of surgery in traumatic intracranial hematomas is to prevent irreversible brain injury or death caused by hematoma expansion, increased ICP, and herniation of the brain.[28–30] An initial assessment of neurologic deficits, pupil abnormalities, degree of midline shift, hematoma volume, and the presence/severity of associated trauma are required to determine the necessity for emergency cranial surgery. For neurosurgeons, one of the most complicated decisions is whether moderate-sized mass lesions should be evacuated or observed. On one hand, surgical intervention might be unnecessary; on the other hand, neurologic deterioration with possible secondary insults to the brain may negatively impact the patient's outcome. Current guidelines and recommendations are available but principally drawn up by experts and the (limited) evidence that is available.[28–30]

Epidural Hematomas

Epidural hematomas (EDH) usually develop in young adults after traffic-related accidents, falls, and assaults.[29] In TBI patients, the incidence of surgical and nonsurgical EDH cases has been estimated between 2.7% to 4%.[29] EDH are thought to result from a direct blow to head and are usually found on the same side impacted by the blow. Typically, the source of bleeding is arterial after a trauma to the sphenoid or temporal bone with subsequent tearing of the middle meningeal artery and hematoma formation in the middle of