

administered on a sliding scale. The minimum dose needed to maintain ICP <20 mm Hg is suggested.

- Bolus of 23.4% hypertonic saline is suggested for refractory ICP. The suggested dose is 0.5 mL/kg with a maximum of 30 mL. (Level II Evidence)
- With use of multiple ICP-related therapies as well as appropriate use of analgesia and sedation in routine intensive care, avoiding bolus administration of midazolam and/or fentanyl during ICP crises is suggested because of risks of cerebral hypoperfusion.
- Cerebrospinal fluid drainage through an external ventricular drain is suggested to manage increased ICP.
- Prophylactic severe hyperventilation to a partial pressure of arterial carbon dioxide <30 mm Hg in the initial 48 hours after injury is not suggested.
- If hyperventilation is used in the management of refractory intracranial hypertension, advanced neuro-monitoring for evaluation of cerebral ischemia is suggested.
- Prophylactic moderate (32°–33°C) hypothermia is not recommended over normothermia to improve overall outcomes.
- Moderate (32°–33°C) hypothermia is suggested for ICP control.
- High-dose barbiturate therapy is suggested in hemodynamically stable patients with refractory intracranial hypertension despite maximal medical and surgical management.
- Decompressive craniectomy is suggested to treat neurologic deterioration, herniation, or intracranial hypertension refractory to medical management.
- Use of an immune-modulating diet is not recommended.
- Initiation of early enteral nutritional support (within 72 hours from injury) is suggested to decrease mortality and improve outcomes.
- The use of corticosteroids is not suggested to improve outcome or reduce ICP.
- Treatment of the patient with severe traumatic brain injury patient is complex, and the recommendations are often difficult to translate into bedside management. Kochanek et al in 2019 established an algorithm for first- and second-tier therapies, in part utilizing the recommendations from the 2019 Guidelines for the Management of Pediatric Severe Traumatic Brain Injury and supplementing with consensus when evidence was insufficient to fully formulate an evidence-based approach.<sup>478</sup> Although the first-tier pathway distinguishes a linear ICP, CPP, brain tissue oxygen (if monitoring), and herniation pathways, the paper specifically noted that treatments may warrant a rapid and nonlinear approach.<sup>478</sup>
- Evaluation and management of post-traumatic seizures: The 2019 Guidelines for the Management of Pediatric Severe Traumatic Brain Injury suggest the use of prophylactic treatment for the first 7 days post-TBI to reduce

the occurrence of early post-traumatic seizures in pediatric patients. References cited in the guidelines include authors citing rates of 2.4% and 17% of early post-traumatic seizures in the pediatric population studied.<sup>479,480</sup> However, the incidence of clinical and nonconvulsive seizures is significantly higher in the patients with AHT with a seizure incidence ranging from 51% to 77%, providing additional evidence for the use of anti-convulsant use in this pediatric subgroup.<sup>480–482</sup> Hasbani et al performed a retrospective study reviewing use of continuous encephalogram (EEG) monitoring in AHT patients at their intensive care unit.<sup>388</sup> Of 32 children admitted during the periods studied, 21 (66%) were monitored with seizures noted in 12 (37.5%) and status epilepticus in 8 (25%). Two-thirds of children never had clinical signs associated with their electrographic seizures; thus, EEG monitoring is required to diagnose and guide acute seizure management. In a larger study performed by O'Neill et al, age less than 2.4 years and AHT mechanism was strongly associated with the presence of seizures (OR, 8.7 and 6.0, respectively).<sup>483</sup> In a prospective study of patients with consecutive moderate to severe TBI admitted to the intensive care unit at 2 institutions, AHT mechanism was a significant risk factor for seizures, with 17 of 22 (77.3%) experiencing seizures.<sup>482</sup> AHT was also a significant risk factor for electrographic-only seizures.

### Surgical Management

A significant number of children presenting with AHT require surgical intervention. In a 5-year review of children presenting to Le Bonheur Children's Hospital, 58 of 213 children with AHT required surgical intervention. Unfortunately, no evidence-based guidelines exist to guide the selection of surgical strategies for the management of the patient with AHT. Case series and pathology-specific literature can guide providers in the care of these patients.<sup>9</sup>

- Skull fractures and epidural hemorrhage: Literature-based guidance regarding the management of depressed skull fractures and epidural hemorrhage is limited. The Brain Trauma Foundation sponsored a "rigorous literature-based" review to provide recommendations for the surgical management of patients with post-traumatic intracranial mass lesions.<sup>462,463</sup> The document provided indications for elevation of open and closed fractures as well as evacuation of epidural hemorrhage on the basis of size and neurologic status of the patient.<sup>484,485</sup>
- Subdural hemorrhage: Fluid collections are common in the subdural space of children who have experienced AHT. Subdural hemorrhagic collections have variable physical properties depending on factors to include the age of blood in the fluid present and include jelly-like