

GUIDELINES FOR THE MANAGEMENT OF ACUTE BLUNT HEAD TRAUMA IN ALASKA

PURPOSE

To guide standardized, evidence-based management of acute head injury in Alaska through early neuroprotection, appropriate consultation and transfer, and support for safe local management when feasible.

BACKGROUND

These guidelines are the efforts of representatives of the Alaska medical community to recommend a reasonable evidence-based approach to head injured patients in our state. This includes regions that do not have access to neurosurgical specialty care. These recommendations are based on our reading of the current medical literature and the experience of clinicians from around the state. This is a multi-disciplinary consensus of local providers and specialists actively caring for head injured patients in Alaska. These guidelines are not meant to replace clinical judgment, but to offer a reasonable approach to these patients.

Traumatic brain injuries (TBIs) represent a significant public health concern in Alaska. As of 2018, Alaska has led the nation in TBI-related deaths, with an average mortality rate of 36.2 per 100,000 individuals, from 2016-2021. TBIs, defined as a head trauma that has resulted in an acquired brain injury, have accounted for over 6.44% of all injury-related hospitalizations with an average of 270 TBI patients every year, per the Alaska Trauma Registry. The care and management of these patients is not only time sensitive, but also reliant on patients being provided access to needed resources, treatments and consultations. This update of the Alaska Head Trauma Guidelines includes alignment with updated national standards and guidance with care practices to encourage capability and improved confidence in rural and remote providers who frequently encounter and manage TBI patients.

Patient transport throughout Alaska is complicated by many factors, geography foremost. Alaska has three distinct regions when considering patient transport. The first, Southcentral region is composed primarily of towns connected to Anchorage by the road system, including the Kenai Peninsula, Matanuska Valley and continuing north to Fairbanks. The second, the Southeast region, is comprised of many island and coastal communities that have transportation and referral ties to both Anchorage and Seattle. The third, the Frontier region, is the remote areas of Alaska, which comprises of villages not on the road system and often great distances from referral medical centers. Many times, transporting patients to definitive neurosurgical care requires aeromedical evacuation. Air ambulance systems are a limited resource within the state and inefficient use reduces their availability for other patients with time-critical emergencies. In addition, because of weather, terrain, longer periods of darkness in winter months, and the vast

distances involved, flying in Alaska is inherently more dangerous for flight crews and patients. The National Institutes of Occupational Safety and Health (NIOSH) reported that commercial pilots flying on commuter airlines or charters in Alaska have a mortality rate five times that of pilots in the rest of the United States. Although the safety of aeromedical evacuation services have improved over time, the risk to patients and flight crews remains an important factor in deciding to transfer patients. The monetary cost of aeromedical transportation continues to increase. Alaska is a national outlier in both the utilization and distance of fixed-wing air ambulance transport. In 2020, Alaska had the highest use of fixed-wing air ambulance services as a proportion of all medical claim lines of any U.S. state. Alaska also recorded the longest average fixed-wing transport distance nationwide, with a mean mileage of 455 miles, several times higher than that observed in most other states, contributing substantially to higher per-transport costs. These risks, costs, and availability must be weighed when considering patient transport across Alaska.

From 2015-2024, TBI cases were reviewed within the Alaska Trauma Registry (ATR). The ATR collects data from 16 facilities around the state and retains data on all patients hospitalized with traumatic injuries; the ATR does not include patients who sought care outside of designated trauma centers (i.e. urgent care facilities, private clinics) and it does not include cases that passed away from their injuries either on scene, or en-route to a trauma center. For these reasons, it is important to understand that the TBIs identified in the ATR only represent a subset of the total amount of TBIs experienced by Alaskans and should be considered as an underestimate of both total TBI frequency and mortality.

Between 2015-2024, there were 42,922 hospitalizations related to injuries, with a total of 2,767 injuries defined as being a TBI (6.44%). 61.8% of TBI cases were male (n=1,711) with an average age of 47.4 years; female TBI patients (n=1,056) had an average age of 51.9 years. The overall age range for TBI patients was 3 months to 101 years old. The most common causes of TBIs within the 10-year period were falls, at 46.3% (n=1,282), followed by motor vehicle accidents (n=277) and assaults (n=276), each causing 10.1% of TBIs. Other land transport vehicles, such as ATVs (n=128), motorcycles (n=87) and snowmachines (n=29), were responsible for roughly 8.8% of TBIs when combined.

Transfer patterns vary amongst the Alaskan Regions. A majority of TBI cases occurred within the Southcentral region (87.7%), which comprises the state's most populous areas, including both Anchorage and Fairbanks, and importantly, this region has access to the road system. Still, in the Southcentral region, transfers of these patients from one trauma center to another is frequent. Within the 10-year period, over 18.4% of all TBI patients injured in the Southcentral region were transferred to a higher level of care (n=447). Higher transfer rates of TBI patients do exist in more remote areas. Within the same 10-year period, the Southeast Region had 10.6% of all TBI cases (n=258) and transferred out 44.9% (n=116). The Frontier region had 3.1% (n=86) of TBI cases and had a transfer rate of 30.2% (n=26).

The average ISS for a patient with a TBI was 12.1, with injuries ranging from a single diagnosis of loss of consciousness, to multiple skull fractures and hemorrhages. 62.9% of TBI patients received imaging (n=1,739), with 45.1% receiving positive results (n=1,247). Within

trauma centers, TBI patients had an average hospital stay of 5.0 days, and admission to the ICU occurred for 23.1% of patients (n=689). 6.3% of all TBI patients required neurosurgical intervention (n=173). The mortality rate associated with TBI patients who were admitted for their injuries was 8.0% (n=220), which is lower than the overall TBI-associated death within Alaska, although it remains substantially higher than the average mortality rate among injured, hospitalized Alaskans (3.2%).

The management of blunt head injuries has been addressed in other regions that share similar challenges of rural transport and scarce specialty resources. Telehealth resources continue to emerge with technologies to help rural and remote areas gain access to specialty care. Teleradiology is now available at all Alaskan hospitals and aids in the evaluation and management of TBI patients. Several studies have shown that head-injured patients can be managed using teleradiology with neurosurgeon review. Telehealth consultations reduce patient transfers with subsequent low rates of late transfer due to either clinical or radiological deterioration.

The Alaska Head Trauma Guidelines were initially written in 2003. At that time, computed tomography (CT) imaging was not widely available. The initial set of guidelines focused on which TBI patients should be transferred to centers with CT imaging availability. Although this may still be relevant for smaller Alaskan clinics to determine transfer needs for imaging, all Alaskan hospitals, and even some larger clinics have now acquired CT scanners. The second revision, in 2017, shifted focus to which TBI patients required transfer for neurosurgical specialty care. Those guidelines also separated out pediatric-specific recommendations, which can now be found in the Alaska Pediatric Head Trauma Guidelines. The 2017 guidelines attempted to define the patients that could safely be kept locally for medical observation with the help of telehealth neurosurgical consultation.

An evaluation of transfer patterns among TBI patients was completed in 2025, both for patients statewide outside of Anchorage that required transfer to a higher level of care, as well as a more targeted evaluation regarding patients injured off-the-road-system in remote Alaska. The evaluation revealed that transfer patterns of TBI patients did not see any significant change after the introduction of the 2017 guidelines, indicating that either the guidelines were not as effective regarding triage and transfer guidance of head trauma patients, or there were external, facility-related factors that guided triage-related decisions of head trauma patients, rather than diagnostic criteria. However, the evaluation did reveal that patients who were most likely to be transferred unnecessarily, whether they came from urban areas vs. rural areas, had common traits such as a GCS of 15, an accompanying diagnosis of loss of consciousness, and negative CT scans. This evaluation helped to guide the direction of this current revision of the Alaska State Adult Head Injury Guidelines.

METHODS

In February 2025 the Alaska Trauma Systems Review Committee (TSRC) convened an ad hoc group to develop consensus recommendations for the evaluation of the acute head-injured patients, focusing on considerations of care in areas without neurosurgical specialty care. The

group consisted of 21 healthcare providers with representatives of pre-hospital care, emergency medicine, trauma surgery, neurosurgery, rural family medicine, trauma nurse leadership, and the Alaska Trauma Database manager. All three levels of trauma centers (II – IV) were represented, as well as all three regional subcommittees. Participants were from both tribal health and private hospital organizations. At the meeting, a literature review was led by three committee members and pertinent articles were distributed to the full committee. In addition, previous Alaska State Adult Head Injury Guidelines, developed in 2003 and 2017 were reviewed. These new guidelines represent the consensus of the committee and are approved by the Alaska Trauma Systems Review Committee.

DEFINITIONS

Acute Head Injury:

Blunt traumatic brain injury (TBI) is a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head. This includes falls that lead to headstrike, including ground level falls. An acute injury is one that is evaluated within 24 hours of the traumatic event. These guidelines do not apply to strokes or hemorrhage not associated with trauma.

Additionally, these guidelines should apply for blunt head trauma and are not recommended for penetrating head trauma. These guidelines apply to isolated head injury and are not recommended for patients who have signs of multi-trauma injuries.

Glasgow Coma Scale (GCS) Score:

The most commonly accepted assessment tool for documenting neurologic status of the head injured patient. (Figure 1)

Canadian CT Imaging Criteria:

Clinicians should perform non-contrast head CT scan on patients with suspected brain injury. Multiple clinical decision tools are available to aid clinician judgement regarding which patients at minimal risk for brain injury not requiring neuroimaging. Although there are several proposed criteria, this working group came to consensus to follow the Canadian CT Head Rule (Figure 2A). In addition, due to the closely related nature of head and neck injuries, all patients with blunt head trauma should be evaluated for the possible need of non-contrast cervical spine (c-spine) imaging. This working group recommends the use of clinical decision rules for cervical spine imaging, which include the Canadian C-Spine Rule (Figure 2B) or NEXUS criteria (Figure 2C).

For patients with severe TBI (GCS 8 or less) or clinical concern for cervical injury, we recommend maintaining spinal motion restriction. Maintaining neutral spine alignment should be a priority during initial management and transfer. For further recommendations of spinal motion restriction and management of spinal cord injuries, please refer to additional guidelines from the Alaska TSRC, “Stabilization and Interfacility Management of Spinal Cord Injuries.”

Initial Clinical Observation:

Neurochecks performed by a health care provider should be done at least hourly for a minimum of six hours, or at an interval deemed appropriate by the provider. The patient should remain at the facility for a health care provider to perform these checks. Clinical observation may be liberalized if the patient returns to GCS 14-15.

Neuroworsening:

Neuroworsening is defined as a decrease of two or more points of the GCS score. Neuroworsening refers to a deterioration in a patient's neurologic status resulting from progression of primary brain injury or the development of secondary intracranial or systemic complications. Because neuroworsening is associated with high mortality and worse functional outcomes in traumatic brain injury, early detection is essential. Trending serial neurologic examinations allow clinicians to identify subtle changes, such as declining consciousness, new focal deficits, or worsening pupillary responses, before they become clinically catastrophic. Regular reassessment is especially important because neuroworsening can occur unpredictably and often signals the need for urgent intervention, including repeat imaging or surgical evaluation.

Neurosurgical Consultation for Transfer:

Current national guidelines for the management of blunt head injury contain guidance on when to obtain a neurosurgical consult, specifically outlined in the Brain Injury Guidelines (BIG). We recognize that the unique geographical and resource-variable setting in Alaska is more suited for early discussion of transfer. Due to the geographic centrality and limited access to facilities with definitive neurosurgical care in Alaska, Small hospitals and Level III, IV, and V trauma centers differ from previous studies applying Brain Injury Guidelines. Thus, the Alaska State Adult Head Injury Guidelines will also address "neurosurgical consultation for transfer." Neurosurgical consultation in Alaska will be initially sought to discuss the benefit of transfer. Further clinical management can be discussed, and, in some cases, if local admission or observation is pursued, it may be appropriate to have continued communication with the neurosurgeon.

Risk factors:

Risk factors are clinical signs, symptoms or history that place the patient at higher risk for clinically significant intracranial injury regardless of GCS.

- **Age 65 or older:** Older patients with injuries have a small increased risk for significant injuries following minor head trauma when compared with younger adults.⁹
- **Anticoagulation:** Anticoagulants include warfarin and direct oral anticoagulants (DOACs). Anti-platelet therapy includes clopidogrel and aspirin. For the purpose of evaluating head injured patients with risk factors, this working group came to consensus to define an increased risk factor due to anti-coagulants/anti-platelet therapy as patients who were using anti-coagulants and/or anti-platelet drug therapy, excluding aspirin therapy alone up to 325mg. Patients who are on anti-coagulants or anti-platelet therapy

pre-injury have been found to be at increased risk of intracranial hemorrhage following blunt head trauma.¹²⁻¹⁵

- **Acute Neurologic Symptoms:** Focal neurologic deficits, new onset seizures, vomiting more than 2 episodes, retrograde amnesia to the event more than 30 minutes.
- **Clinical signs of skull fracture:** Clinical signs of a basilar skull fracture include periorbital ecchymosis (raccoon's eyes), retroauricular ecchymosis (Battle's sign), hemotympanum, or cerebrospinal fluid leak from the nose (rhinorrhea) or ear (otorrhea). Skull x-rays are not recommended in the diagnosis of skull fracture or head injury.
- **Dangerous mechanism of injury:** High velocity mechanisms may lead to higher force if headstrike occurs and should be evaluated with a higher suspicion of intracranial hemorrhage. These include pedestrian struck, ejection from a motor vehicle crash (MVC), and falls from greater than 3 feet.

SPECIAL CONSIDERATIONS

Alcohol and drug use:

Healthcare providers should be aware that alcohol and drug use may limit the utility of the Glasgow Coma Scale as a triage tool in patients with suspected head injury. Patients who have signs or measured values of alcohol or drug intoxication must be evaluated for exam findings of head trauma, such as ecchymosis or scalp lacerations. Signs of trauma combined with impaired GCS may prompt clinicians to obtain CT imaging sooner. If there are no signs of external trauma, but impaired GCS ≤ 13 , patients should be monitored by a healthcare provider with observation at regular intervals per provider discretion. If there is any neuroworsening, a head CT scan should be obtained. If there is no clinical improvement (return to GCS 15) within six hours or an interval consistent with local practice guidelines, a head CT scan should be obtained.

Metabolic Derangements:

Metabolic derangements are a critical and common cause of altered mental status, and clinicians must rapidly evaluate for and rule them out early in the assessment. Immediate bedside glucose testing is essential, as hypoglycemia is a frequent, reversible cause requiring prompt dextrose administration when detected. A comprehensive metabolic panel should be obtained to assess for electrolyte disturbances such as hypernatremia, hyponatremia, and calcium abnormalities, which are well-established contributors to toxic-metabolic encephalopathy and global cerebral dysfunction. Renal and hepatic function must also be evaluated, as uremia and hepatic encephalopathy are additional reversible causes of altered mental status. Identifying and correcting these abnormalities early is essential to prevent further neurologic deterioration or permanent injury.

Children and infants:

Evaluation of head trauma in infants and children also presents challenges. The purpose of these guidelines is to recommend clinical practice for adults 18 years of age and older.

Pediatric patients under 18 years of age are covered by the Alaska Pediatric Head Trauma Guidelines.

RECOMMENDATIONS FOR IMAGING (Figure 4)

Patients with normal GCS (15) without risk factors: Patients who have a normal GCS exam of 15 without risk factors are unlikely to require medical or surgical intervention for a traumatic brain injury.¹⁶ Based on the Canadian CT Head Rule, these patients do not require CT imaging. They may be discharged with a competent observer. These guidelines recommend discharging the patient with a head injury patient education sheet (Figure 3).

Patients with GCS 14 without risk factors: Patients with a GCS of 14 without risk factors may undergo clinical observation. If the patient's mental status returns to normal (GCS 15) within two hours, these patients do not require CT imaging and may be discharged with a competent observer and a head injury patient education sheet (Figure 3). However, if the patient does not improve to a GCS of 15 within two hours of clinical observation, we recommend obtaining a head CT without contrast, and consideration of a non-contrast C-spine CT if clinically indicated. Spinal motion restriction should be maintained in the care of the patient.

Patients with GCS 9-13 or GCS 14-15 with risk factors: We recommend that all of these patients undergo a head CT without contrast, and consideration of a non-contrast C-spine CT if clinically indicated.

Patients with GCS 8 or less: These critically injured patients require stabilization with the goal of avoiding secondary brain injury. The patient should initially be optimized with protection of the airway, avoidance of hypoxia ($\text{SpO}_2 < 93\%$) and hypotension ($\text{SBP} < 110\text{mmHg}$), maintenance of normocarbida (ETCO_2 35-45) and normothermia, elevation of the head of bed to greater than thirty degrees, and spinal motion restriction. These patients should then be transferred to a Trauma Center with neurosurgical capabilities. A non-contrast CT of the head and c-spine should be obtained if this does not delay transfer and if the patient is clinically stable for radiographic imaging.

If injury occurs in a remote clinic, these severely injured patients do not require primary transfer to a regional facility to obtain a CT scan; consideration of transfer directly to a Trauma Center with neurosurgical capabilities is recommended. If no imaging has been obtained, consultation for transfer should be directed to the Trauma Surgery in lieu of neurosurgical consultation.

MANAGEMENT OF PATIENTS WITH NORMAL CT IMAGING (Figure 4)

Patients with normal GCS (15) or GCS 14 without risk factors and normal CT imaging: We recommend consideration of initial clinical observation locally. The patient may be discharged with a competent observer and head injury patient education sheet when GCS returns to 15.

Patients with GCS 9-13 or GCS 14-15 with risk factors and normal CT imaging: If after a period of initial clinical observation, the GCS score remains 9-13, we recommend local

admission for continued observation. If there is neuroworsening, defined as a GCS drop of two or more points, or if the patient does not return to GCS of 15 within twenty-three hours of clinical observation, the patient should undergo prompt repeat head CT. At any time, a patient may be discharged with a competent observer and head injury patient education sheet when GCS returns to 15. For patients who were transported to the regional facility for CT imaging, we recommend keeping the patient locally at the regional facility for a minimum of 24 hours from injury in case of neuroworsening.

Patients with GCS 8 or less and normal CT imaging: If the GCS score is 8 or less, despite normal CT imaging, we recommend prompt consultation for transfer with a Trauma Center with neurosurgical capabilities. These critically injured patients require stabilization with the goal of avoiding secondary brain injury. The patient should initially be optimized with protection of the airway, avoidance of hypoxia ($\text{SpO}_2 < 93\%$) and hypotension ($\text{SBP} < 110\text{mmHg}$), maintenance of normocarbia (ETCO_2 35-45) and normothermia, elevation of the head of bed to greater than thirty degrees, and spinal motion restriction. Consultation for transfer should be directed to the Trauma Surgery in lieu of neurosurgical consultation.

Neuroprotection should include:

- Avoidance of hypoxia: $\text{SpO}_2 < 93\%$
- Avoidance of hypotension: $\text{SBP} < 110\text{mmHg}$
- Maintenance of normocarbia: ETCO_2 35-45
- Maintenance of normothermia: $36.5^\circ\text{C} - 37.5^\circ\text{C}$ ($97.7^\circ\text{F} - 99.5^\circ\text{F}$)

ALASKA BRAIN INJURY GUIDELINES (AK-BIG)

We developed Alaska-specific Brain Injury Guidelines (AK-BIG) guidelines (Figure 5), with guidance from the national modified Brain Injury Guidelines (m-BIG). AK-BIG therapeutic plan differs from the m-BIG with the additional category of transfer. This is to allow for the guidance of transfer management of TBI patients at facilities without neurosurgical capabilities. Due to this additional category of care guidelines, the AK-BIG 2 was extended to include patients on anticoagulation. In some instances, a facility may be capable of admitting these patients with planned repeat head CT and frequent neurochecks. This is likely more applicable to facilities on the road system with ability for rapid transfer to a Trauma Center with neurosurgical capabilities if neuroworsening or progression of intracranial hemorrhage on repeat imaging occurs. In addition, we recommend neurosurgical consultation for transfer in the therapeutic plan for AK-BIG 2 in order to support local clinicians in the management and transfer decisions for these more moderate TBI patients. **Acknowledging the remoteness of many of our facilities, we chose to expand the neurosurgical consultation support recommendations. This may allow facilities to become more capable of admitting patients locally when clinically appropriate.** If neurosurgical consult is pursued, images should be sent via teleradiology for review.

ACUTE MANAGEMENT AND STABILIZATION:

Resuscitation:

Resuscitation of TBI patients should first focus on ruling out and treating hemorrhagic shock, which remains the most common cause of shock in trauma. The greatest priority is the avoidance of hypotension (systolic blood pressure <110 mmHg), as even a single episode is associated with increased mortality. Initial resuscitation should prioritize early blood product administration in patients at risk for hemorrhagic shock, with balanced resuscitation strategies (including plasma and/or whole blood) favored over large-volume crystalloid use. If crystalloid is used, it should be limited to isotonic solutions, specifically normal saline. Hypotonic fluids and dextrose-containing solutions should be avoided due to the risk of worsening cerebral edema and increasing intracranial pressure. If adequate blood pressure cannot be achieved after appropriate volume resuscitation and hemorrhage control, vasopressor therapy may be indicated to maintain cerebral perfusion. These agents should be used with caution and, when possible, with Trauma Center consultation to avoid masking ongoing hypovolemia.

Hyperosmolar agents:

Hyperosmolar therapy is used in the care of patients with severe TBI to lower intracranial pressure (ICP). Mannitol and hypertonic saline are the most commonly used agents, but are varied in their availability around the state of Alaska. There are risks involved with the use of these agents, and patient condition should inform the selection of a specific agent. Hypertonic saline administration may be hazardous for a hyponatremic patient. Mannitol has a profound diuretic effect and can cause hypotension. It should be used with caution to avoid secondary brain injury as even a single episode of hypotension can worsen TBI outcomes. There is no national consensus on the effect hyperosmolar agents have on clinical outcomes. However, we recognize that given the challenges of prolonged transport and delay of definitive neurosurgical care in Alaska, **hyperosmolar therapy may benefit AK-BIG 3 patients.** Use should be directed by neurosurgical consultation, and if available, hyperosmolar agents should be initiated prior to arrival at the Trauma Center with neurosurgical capabilities. Hyperosmolar therapy may be initiated at the local facility or with aeromedical transport teams depending on the availability of these agents. Hyperosmolar therapy can be safely administered via peripheral IV. We do not recommend delay in transfer to obtain central access for administration of hyperosmolar therapy.

Anti-convulsant therapy:

Patients with severe TBI are at risk for acute seizures. Additional risk factors include GCS score of 10 or less, amnesia lasting more than 30 minutes, presence of a skull fracture, intracranial hemorrhage, age 65 years or older, and chronic alcoholism. The highest risk of post-traumatic seizures is within 7 days of injury. Anti-convulsant therapy can be used to prevent seizures following TBI. Seizure prophylaxis has potential benefit to prevent the development of chronic epilepsy, herniation, and death. The most common agents used include levetiracetam and phenytoin or fosphenytoin. Although there is not national consensus regarding the preferred use

of one agent over the other, due to the wide availability in Alaska and lower side effect profile, we recommend the use of levetiracetam.

We recognize that given the challenges of prolonged transport and delay of definitive neurosurgical care in Alaska, **early anti-convulsant therapy may benefit AK-BIG 3 patients.** Use should be directed by neurosurgical consultation, and if available, an initial prophylactic dose of 1,000mg IV levetiracetam should be initiated prior to arrival at the Trauma Center with neurosurgical capabilities. This medication may be initiated at the local facility or with aeromedical transport teams depending on the availability of these agents. For prolonged delay of transport, prophylactic therapy should be continued at 500mg IV levetiracetam every 12 hours.

For patients with active seizures, initial treatment should be with benzodiazepines per local protocols. Loading dose of levetiracetam at 60mg/kg or 4,500mg maximum dose should be administered. For refractory seizures, prompt expert consultation should be obtained.

AK-BIG 2 patients with high-risk characteristics of a non-displaced skull fracture, age 65 years or older, or chronic alcoholism may be considered for early anti-convulsant therapy. We recommend neurosurgical consultation to guide initiation of seizure prophylaxis.

Sedation and Analgesia:

Analgesics and sedatives are important and commonly used therapies in acute head injury. Local protocols and drug availability widely varies around Alaska. **Careful consideration of side effects, including hypotension and metabolic effects is necessary.** Additionally, administration of these medications may preclude the physical examination. In intubated patients, **shorter acting medications should be considered to allow for repeated clinical examinations;** monitoring of sedative doses need to be diligently observed.

Tranexamic Acid:

Tranexamic acid (TXA) has become an accepted part of protocols for the treatment of injured patients with hypotension and possible uncontrolled hemorrhage. **Head injury is not a contraindication to TXA use and has showed some improvement in survival in patients with mild to moderate head injuries when given within 3 hours.** A TXA protocol using a single 2 gram dose is the preferred method for administering TXA in the prehospital setting. Inpatient protocols may give 1 gram bolus followed by an additional 1 gram infused over eight hours.

Care guidelines for admitted patients:

Patients admitted to a local hospital without neurosurgical capabilities require guidance for medical management and continued monitoring of TBI patients. **If AK-BIG 2 patients are admitted locally, neurosurgical consultation should guide the following:**

- **Frequency of neurochecks:** Resources will vary at local hospitals and should guide the capability of care for TBI patients. Neurochecks should include, at a minimum, documentation of GCS score and pupil size and reactivity.

Neurochecks should be evaluated and recorded and frequent short intervals until GCS returns to 15. Neurochecks should continue at a minimum of every 4 hours while admitted. If neuroworsening (decrease of 2 or more points in GCS score) or a new asymmetric pupillary exam occurs, a prompt CT Head should be obtained with a consultation to a neurosurgeon.

- **Hemodynamic parameters:** TBI patients should be kept normotensive. Avoidance of both hypotension and hypertension is recommended. In moderate to severe TBI, SBP should be maintained at 110mmHg or above for optimal cerebral perfusion. If the patient becomes hemodynamically abnormal, a consultation to a Trauma Center with neurosurgical capabilities should be obtained.
- **Repeat Head CT:** Most AK-BIG 2 patients will not require repeat head CT. However, for AK-BIG 2 patients on anti-coagulation, a scheduled repeat CT head is recommended. This should be obtained around 6 hours after initial head CT. If stable, continue non-operative management at local hospital. If there are worsened changes on repeat head CT, a prompt consultation to a neurosurgeon should occur.
- **Management of patients on anticoagulants:** Treatment is individualized and should prompt a discussion with the consulting neurosurgeon. When available, laboratory data including CBC, PTT, INR, and fibrinogen should be obtained. Consideration of discontinuation, reversal, and timing for re-initiation should be a multi-disciplinary discussion and may include other medical specialists.

NON-SALVAGEABLE HEAD INJURIES

There are patients with severe TBI who have sustained injuries thought to be non-survivable. These patients should initially be optimized with neuroprotective measures. A non-contrast CT of the head and c-spine should be obtained if this does not delay transfer and if the patient is clinically stable for radiographic imaging. If CT imaging shows a devastating intracranial hemorrhage or herniation, consult neurosurgery at a Trauma Center to assist with decision-making. **In some circumstances, it may be appropriate to not transfer a patient to a Trauma Center with neurosurgical capabilities because it ultimately does not change outcomes and separates a patient from his/her family and community at end of life.** It is also costly and potentially dangerous to both patient and transport teams. Consider also contacting organ donation services for these patients; it may be appropriate to transport patients with non-survivable injuries who are registered organ donors or whose families express interest in organ donation.

EMERGENCY CRANIOTOMY

In severely injured patients, neuroprotection is paramount. In patients with rapidly deteriorating clinical exam and evidence of lateralizing pupil exam, emergency surgical decompression is critical to survival. This is best performed by a neurosurgeon. Neurosurgical

procedures should not be performed by practitioners in other disciplines. International data demonstrates poor outcomes that result when non-neurosurgeons perform neurotrauma procedures, including technically substandard operations and major delays in definitive neurosurgical intervention. Appropriate care of patients with neurosurgical emergencies is labor and resource intensive, requiring specialty equipment and trained personnel. **Emergency craniotomy by a non-neurosurgeon is not recommended in Alaska; focus of care should be on neuroprotection and rapid transfer to a Trauma Center with neurosurgical capabilities.**

CONCLUSIONS

Outlined here is an approach to the evaluation of head-injured patients in Alaska, including facilities that do not have a neurosurgeon available. It is an attempt to combine a reading of the current literature with the realities of medical practice and resource availability in our state. It is not meant to replace clinical judgment. There are limits to the applicability of these guidelines including complex social considerations, patients under the influence of drugs or alcohol and remote medical treatment facilities with minimal staff. Additionally, recommendations for pediatric patients under 18 years of age are covered separately by the Alaska Pediatric Head Injury Guidelines.

Our state is unique in the factors that may play into transporting patients for in-person neurosurgical care, especially the frequent need for aeromedical transport and delays in care. **Our hope is that this will offer some guidance to clinicians faced with caring for the head-injured patient in a very challenging environment. In addition, it will help us to utilize our transport and subspecialty resources in a safe, responsible, and efficient manner.**

Figure 1: Glasgow Coma Scale

Eye(s) Opening

Spontaneous	4
To speech	3
To pain	2
No response	1

Verbal Response

Oriented to time, place, person	5
Confused/disoriented	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1

Best Motor Response

Obeys commands	6
Moves to localized pain	5
Flexion withdraws from pain	4
Abnormal flexion	3
Abnormal extension	2
No response	1

Figure 2: Clinical Decision Rules for Head and Cervical Spine Imaging Criteria

A) Canadian CT Head Rule:

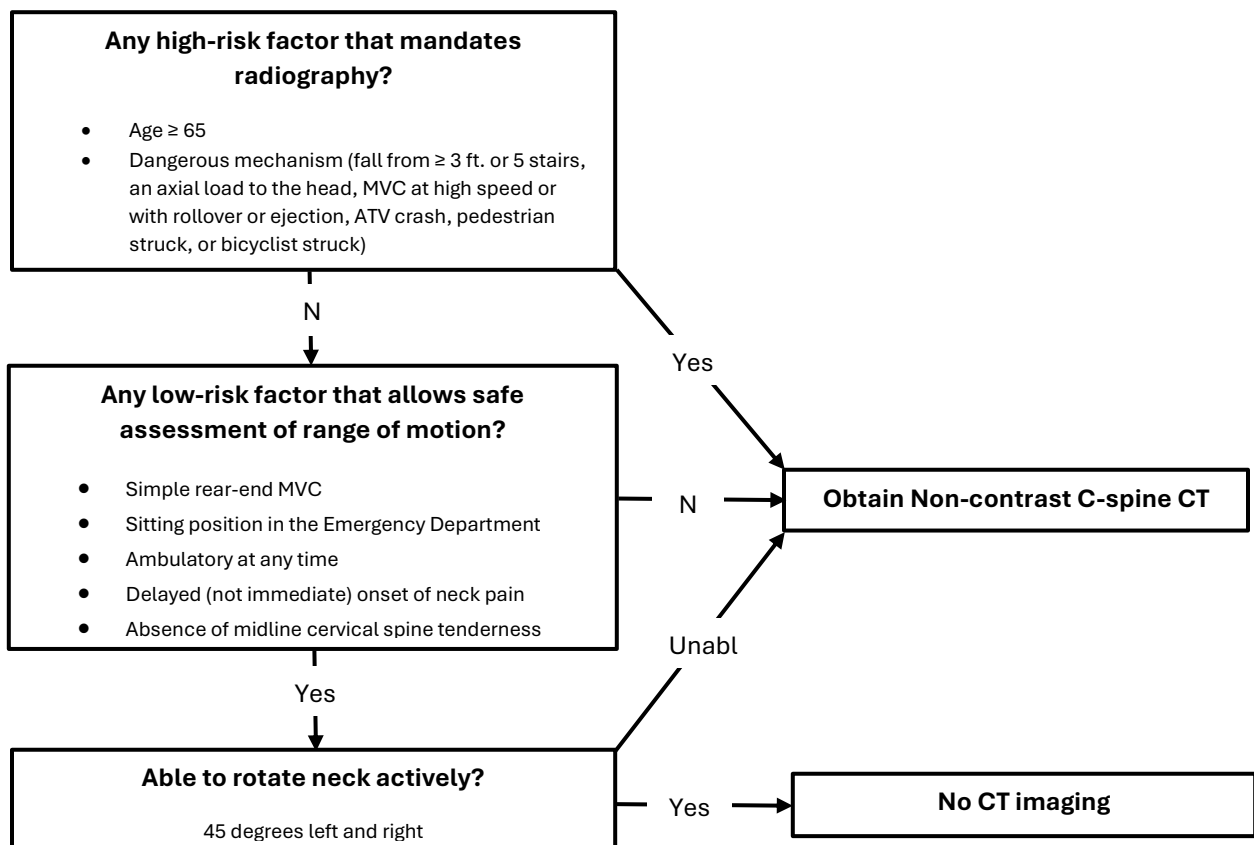
A non-contrast head CT should be considered in head trauma patients with no LOC or post-traumatic amnesia if there are any of the following factors present:

- Suspected open or depressed skull fracture
- Signs of basilar skull fracture (hemotympanum, raccoon eyes, Battle's sign, otorrhea/rhinorrhea)
- 2 or more episodes of vomiting
- Age ≥ 65
- Failure to reach GCS 15 within 2 hours of injury
- Retrograde amnesia to the event ≥ 30 minutes
- Dangerous mechanism of injury (pedestrian struck, ejected from MVC, fall from > 3 feet)

****These criteria exclude age < 16 , use of blood thinners, or patients with seizure after injury.**

Canadian C-Spine Rule:

These guidelines apply to trauma patients who are alert (GCS 15) and in stable condition.



C) NEXUS Criteria for Cervical Spine Imaging

These guidelines apply to trauma patients who are alert (GCS 15) and in stable condition.

Cervical spine imaging is NOT required if ALL the following are present:

- No midline cervical tenderness
- No focal neurologic deficit
- Normal level of alertness
- No intoxication
- No painful distracting injury

If ANY of the above are absent, cervical spine imaging is recommended.



Mild Traumatic Brain Injury and Concussion: Information for Adults

Discharge Instructions

You were seen today for a mild traumatic brain injury (mild TBI) or concussion.



Use this handout to help you watch for changes in how you are feeling or acting and to help you feel better.



Be sure to let a family member or friend know about your injury and the types of symptoms to look out for. They may notice symptoms before you do and can help you.



Schedule a follow-up appointment with your regular doctor.

Due to your injury, you may need to take some time off from things like work or school. If so, ask your doctor for written instructions about when you can safely return to work, school, sports, or other activities such as driving a car, riding a bike, or operating heavy equipment.



Watch for Danger Signs

In rare cases, a dangerous blood clot that crowds the brain against the skull can develop after a TBI. The people checking on you should call 911 or take you to an emergency department right away if you have:

- A headache that gets worse and does not go away
- Significant nausea or repeated vomiting
- Unusual behavior, increased confusion, restlessness, or agitation
- Drowsiness or inability to wake up
- Slurred speech, weakness, numbness, or decreased coordination
- Convulsions or seizures (shaking or twitching)
- Loss of consciousness (passing out)

More information on mild TBI and concussion, as well as tips to help you feel better, can be found at www.cdc.gov/TraumaticBrainInjury.



Learn About Your Injury

Mild TBI and concussions are brain injuries. A mild TBI or concussion is caused by a bump, blow, or jolt to the head or body that causes:



The head and brain to move quickly back and forth.



The brain to bounce or twist in the skull from this sudden movement.



Chemical changes in the brain and sometimes stretching and damage to the brain cells.

Doctors may describe these injuries as “mild” brain injuries because they are usually not life-threatening. Even so, their effects can be serious.

Mild TBI and concussion signs and symptoms are part of the normal healing process.

Some mild TBI and concussion symptoms (listed at right) may appear right away, while other symptoms may not appear for hours or days after the injury. Symptoms generally improve over time, and most people will feel better within a couple of weeks. If you have symptoms that concern you or are getting worse, be sure to talk with your doctor.

Symptoms of mild TBI and concussion may affect how you feel, think, act, or sleep.

Symptoms of mild TBI and concussion are different for each person. Most people will have one or more symptoms that affect how they feel, think, act, or sleep. Symptoms may change during recovery. For example, you may have headaches and feel sick to your stomach right after the injury. A week or two after your injury you may notice other symptoms, like feeling more emotional than usual or having trouble sleeping.

Symptoms of Mild TBI and Concussion



Physical

- Bothered by light or noise
- Dizziness or balance problems
- Feeling tired, no energy
- Headaches
- Nausea or vomiting (early on)
- Vision problems



Thinking and Remembering

- Attention or concentration problems
- Feeling slowed down
- Feeling foggy or groggy
- Problems with short-term memory
- Problems with long-term memory
- Trouble thinking clearly



Emotional

- Anxiety or nervousness
- Irritability or easily angered
- Feeling more emotional
- Sadness



Sleep

- Sleeping *less* than usual
- Sleeping *more* than usual
- Trouble falling asleep

Understand Your Recovery

Start your recovery by resting. As symptoms improve, you may gradually return to regular activities.

Recovery from a mild TBI or concussion means you can do your regular activities without experiencing symptoms from the injury. Recovery may be slower among older adults. People who have had a brain injury in the past may also find that it takes longer to recover.

The First Few Days

- Start your recovery by resting. Symptoms are generally more severe the first few days after the injury.
- You may need to take a short time off from work or school, although usually no more than 2 to 3 days.
- Ask your doctor for written instructions about when you can safely return to work, school, or other activities, such as driving a car.



As You Start to Feel Better

- As you start to feel better after the first few days of your injury, you can gradually return to regular (non-strenuous) activities, such as taking a short walk.
- Avoid activities that make your symptoms come back or get worse.
- For a short time, you may need extra help or support, such as rest breaks or fewer hours at work or school.



When Symptoms Are Nearly Gone

- When your symptoms are mild and nearly gone, return to most regular activities.
- If your symptoms do not get worse during an activity, then that activity is OK for you.
- If your symptoms get worse, you should cut back on that activity.

Taking these steps may help speed your recovery:

- Avoid activities that can put you at risk for another injury to your head and brain.
- Stay connected to friends and family and talk with them about how you are feeling.
- Ask your doctor about medications that are safe to take during recovery to help with symptoms (for example, ibuprofen or acetaminophen for headaches).
- Limit screen time and loud music before bed, sleep in a dark room, and keep to a fixed bedtime and wake-up schedule.

Do not return to sports and recreational activities on the same day of your injury; wait until you get the OK from a doctor.

A repeat brain injury that occurs before the brain has fully healed may slow your recovery or increase the chance for long-term problems. This risk is especially a concern for teens and young adults. Returning to sports and recreational activities is a gradual process and should be carefully managed and monitored by your doctor.

If you do not think you are getting better or your symptoms are getting worse, tell your doctor.

Keep track of your mild TBI or concussion symptoms and share this information with your doctor. This information may help them identify the best treatments for your symptoms. You may also need to see a specialist who has experience treating brain injuries. Your doctor can help link you to brain injury specialists and services in your area.

If the injury is affecting your ability to work or go to school, talk with your employer or school about support services that may be available to you. If your injury was work-related, make sure you report it right away to your employer and your workers' compensation office.

More information on mild TBI and concussion, as well as tips to help you feel better, can be found at www.cdc.gov/TraumaticBrainInjury.

Additional Notes:

The information provided in this handout or through links to other sites is not a substitute for medical or professional care. Questions about diagnosis and treatment for concussion should be directed to your doctor or other healthcare provider.

Figure 5: Alaska Brain Injury Guidelines (AK-BIG)

ALASKA BRAIN INJURY GUIDELINES			
VARIABLES	AK-BIG 1	AK-BIG 2	AK-BIG 3
Initial GCS	13 - 15	13 - 15	Any
Abnormal Neurologic Examination	No	No	Yes
Intoxication	No	No/Yes	No/Yes
Anticoagulation**	No	No/Yes	Yes
Skull Fracture	No	Non-displaced	Displaced
SDH	≤ 4mm	4 – 7.9 mm	≥ 8mm
EDH	None	≤ 7 mm	≥ 8mm
IPH	≤ 4mm	4 – 7.9 mm	≥ 8mm or multiple
SAH	≤ 3 sulci and < 1 mm	Single hemisphere or 1 – 3 mm	Bi-hemispheric or > 3mm
IVH	No	No	Yes
-SEND IMAGES FOR REVIEW WHEN REQUESTING NEUROSURGICAL CONSULT-			
THERAPEUTIC PLAN			
Hospitalization	No Initial Observation (6hrs) <i>Keep local for 24 hours from injury</i>	Yes	Yes
Transfer	No	No/Yes <i>May admit locally if capable</i>	Yes <i>Transfer to higher level Trauma Center with Neurosurgical Capabilities</i>
Repeat Head CT	No	No <i>Yes – if on anticoagulation**</i>	Yes
Neurosurgical Consult for Transfer	No	Yes	Yes

Alaska Head Injury Selected References:

Epidemiology

https://epi.alaska.gov/bulletins/docs/rr2023_02.pdf

Newell K, Parrish J, McLaughlin J. Traumatic Brain Injury, Alaska, 2016-2021. Public Health Rep. 2025 Mar-Apr;140(2-3):255-264. doi: 10.1177/00333549241309802. Epub 2025 Apr 28. PMID: 40293118; PMCID: PMC12037538.

Bhogadi SK, Stewart C, Hosseinpour H, Nelson A, Ditillo M, Matthews MR, Magnotti LJ, Joseph B. Outcomes of Patients With Traumatic Brain Injury Transferred to Trauma Centers. JAMA Surg. 2024 Nov 1;159(11):1282-1288. doi: 10.1001/jamasurg.2024.3254. PMID: 39196585; PMCID: PMC11359096.

Zakrison TL, Bolaji T, Chaudhary MJ. Traumatic Brain Injury Transfers-Balancing Resources and Equity. JAMA Surg. 2024 Nov 1;159(11):1289-1290. doi: 10.1001/jamasurg.2024.3251. PMID: 39196569.

Bonow RH, Quistberg A, Rivara FP, Vavilala MS. Intensive Care Unit Admission Patterns for Mild Traumatic Brain Injury in the USA. Neurocrit Care. 2019 Feb;30(1):157-170. doi: 10.1007/s12028-018-0590-0. PMID: 30136076.

EMS and Prehospital Care

Lulla A, Lumba-Brown A, Totten AM, Maher PJ, Badjatia N, Bell R, Donayri CTJ, Fallat ME, Hawryluk GWJ, Goldberg SA, Hennes HMA, Ignell SP, Ghajar J, Krzyzaniak BP, Lerner EB, Nishijima D, Schleien C, Shackelford S, Swartz E, Wright DW, Zhang R, Jagoda A, Bobrow BJ. Prehospital Guidelines for the Management of Traumatic Brain Injury - 3rd Edition. Prehosp Emerg Care. 2023;27(5):507-538. doi: 10.1080/10903127.2023.2187905. Epub 2023 Apr 20. PMID: 37079803.

Maiga AW, Lin HS, Wisniewski SR, Brown JB, Moore EE, Schreiber MA, Joseph B, Wilson CT, Cotton BA, Ostermayer DG, Harbrecht BG, Patel MB, Sperry JL, Guyette FX, Wang HE. Adverse Prehospital Events and Outcomes After Traumatic Brain Injury. JAMA Netw Open. 2025 Jan 2;8(1):e2457506. doi: 10.1001/jamanetworkopen.2024.57506. PMID: 39888614; PMCID: PMC11786231.

Spaite DW, Bobrow BJ, Keim SM, Barnhart B, Chikani V, Gaither JB, Sherrill D, Denninghoff KR, Mullins T, Adelson PD, Rice AD, Viscusi C, Hu C. Association of Statewide Implementation of the Prehospital Traumatic Brain Injury Treatment Guidelines With

Patient Survival Following Traumatic Brain Injury: The Excellence in Prehospital Injury Care (EPIC) Study. *JAMA Surg.* 2019 Jul 1;154(7):e191152. doi: 10.1001/jamasurg.2019.1152. Epub 2019 Jul 17. PMID: 31066879; PMCID: PMC6506902.

Guidelines

<https://www.facs.org/media/vgfgjpfk/best-practices-guidelines-traumatic-brain-injury.pdf>

American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Mild Traumatic Brain Injury; Valente JH, Anderson JD, Paolo WF, Sarmiento K, Tomaszewski CA, Haukoos JS, Diercks DB; Members of the American College of Emergency Physicians Clinical Policies Committee (Oversight Committee); Diercks DB, Anderson JD, Byyny R, Carpenter CR, Friedman B, Gemme SR, Gerardo CJ, Godwin SA, Hahn SA, Hatten BW, Haukoos JS, Kaji A, Kwok H, Lo BM, Mace SE, Moran M, Promes SB, Shah KH, Shih RD, Silvers SM, Slivinski A, Smith MD, Thiessen MEW, Tomaszewski CA, Trent S, Valente JH, Wall SP, Westafer LM, Yu Y, Cantrill SV, Finnell JT, Schulz T, Vandertulip K. Clinical Policy: Critical Issues in the Management of Adult Patients Presenting to the Emergency Department With Mild Traumatic Brain Injury: Approved by ACEP Board of Directors, February 1, 2023 Clinical Policy Endorsed by the Emergency Nurses Association (April 5, 2023). *Ann Emerg Med.* 2023 May;81(5):e63-e105. doi: 10.1016/j.annemergmed.2023.01.014. PMID: 37085214; PMCID: PMC10617828.

Chesnut RM, Temkin N, Videtta W, Petroni G, Lujan S, Pridgeon J, Dikmen S, Chaddock K, Barber J, Machamer J, Guadagnoli N, Hendrickson P, Aguilera S, Alanis V, Bello Quezada ME, Bautista Coronel E, Bustamante LA, Cacciatori AC, Carricondo CJ, Carvajal F, Davila R, Dominguez M, Figueroa Melgarejo JA, Fillipi MM, Godoy DA, Gomez DC, Lacerda Gallardo AJ, Guerra Garcia JA, Zerain GF, Lavadenz Cuentas LA, Lequipe C, Grajales Yuca GV, Jibaja Vega M, Kessler ME, López Delgado HJ, Sandi Lora F, Mazzola AM, Maldonado RM, Mezquia de Pedro N, Martínez Zubieta JR, Mijangos Méndez JC, Mora J, Ochoa Parra JM, Pahnke PB, Paranhos J, Piñero GR, Rivadeneira Pilacuan FA, Mendez Rivera MN, Romero Figueroa RL, Rubiano AM, Saraguro Orozco AM, Silesky Jiménez JI, Silva Naranjo L, Soler Morejon C, Urbina Z. Consensus-Based Management Protocol (CREVICE Protocol) for the Treatment of Severe Traumatic Brain Injury Based on Imaging and Clinical Examination for Use When Intracranial Pressure Monitoring Is Not Employed. *J Neurotrauma.* 2020 Jun 1;37(11):1291-1299. doi: 10.1089/neu.2017.5599. Epub 2020 Mar 4. PMID: 32013721; PMCID: PMC7249475.

Godoy DA, Murillo-Cabezas F, Suarez JI, Badenes R, Pelosi P, Robba C. "THE MANTLE" bundle for minimizing cerebral hypoxia in severe traumatic brain injury. *Crit Care.* 2023 Jan 12;27(1):13. doi: 10.1186/s13054-022-04242-3. PMID: 36635711; PMCID: PMC9835224.

Picetti E, Catena F, Abu-Zidan F, Ansaloni L, Armonda RA, Bala M, Balogh ZJ, Bertuccio A, Biffi WL, Bouzat P, Buki A, Cerasti D, Chesnut RM, Citerio G, Coccolini F, Coimbra R, Coniglio C, Fainardi E, Gupta D, Gurney JM, Hawryluk GWJ, Helbok R, Hutchinson PJA, Iaccarino C, Koliass A, Maier RW, Martin MJ, Meyfroidt G, Okonkwo DO, Rasulo F, Rizoli S, Rubiano A, Sahuquillo J, Sams VG, Servadei F, Sharma D, Shutter L, Stahel PF, Taccone FS, Udy A, Zoerle T, Agnoletti V, Bravi F, De Simone B, Kluger Y, Martino C, Moore EE, Sartelli M, Weber D, Robba C. Early management of isolated severe traumatic brain injury patients in a hospital without neurosurgical capabilities: a consensus and clinical recommendations of the World Society of Emergency Surgery (WSES). *World J Emerg Surg.* 2023 Jan 9;18(1):5. doi: 10.1186/s13017-022-00468-2. Erratum in: *World J Emerg Surg.* 2023 Apr 6;18(1):29. doi: 10.1186/s13017-023-00489-5. PMID: 36624517; PMCID: PMC9830860.

Head CT

Easter JS, Haukoos JS, Meehan WP, Novack V, Edlow JA. Will Neuroimaging Reveal a Severe Intracranial Injury in This Adult With Minor Head Trauma?: The Rational Clinical Examination Systematic Review. *JAMA.* 2015 Dec 22-29;314(24):2672-81. doi: 10.1001/jama.2015.16316. Erratum in: *JAMA.* 2017 May 16;317(19):2021. doi: 10.1001/jama.2017.5136. PMID: 26717031.

BIG

Joseph B, Obaid O, Dultz L, Black G, Campbell M, Berndtson AE, Costantini T, Kerwin A, Skarupa D, Burruss S, Delgado L, Gomez M, Mederos DR, Winfield R, Cullinane D; AAST BIG Multi-institutional Study Group. Validating the Brain Injury Guidelines: Results of an American Association for the Surgery of Trauma prospective multi-institutional trial. *J Trauma Acute Care Surg.* 2022 Aug 1;93(2):157-165. doi: 10.1097/TA.0000000000003554. Epub 2022 Mar 28. PMID: 35343931.

Khan AD, Lee J, Galicia K, Billings JD, Doharia V, Patel PP, McIntyre RC, Gonzalez RP, Schroepel TJ. A multicenter validation of the modified brain injury guidelines: Are they safe and effective? *J Trauma Acute Care Surg.* 2022 Jul 1;93(1):106-112. doi: 10.1097/TA.0000000000003633. Epub 2022 Apr 1. PMID: 35358157.

Tourigny JN, Boucher V, Paquet V, Fortier É, Malo C, Mercier É, Chauny JM, Clark G, Blanchard PG, Carmichael PH, Gariépy JL, D'Astous M, Émond M. External validation of the updated Brain Injury Guidelines for complicated mild traumatic brain injuries: a retrospective cohort study. *J Neurosurg.* 2022 Jan 25;137(3):782-788. doi: 10.3171/2021.10.JNS211794. PMID: 35078154.

Shen A, Mizraki N, Maya M, Torbati S, Lahiri S, Chu R, Margulies DR, Barmmparas G. Reducing low-value interhospital transfers for mild traumatic brain injury. *J Trauma Acute Care Surg.* 2024 Jun 1;96(6):944-948. doi: 10.1097/TA.00000000000004291. Epub 2024 Mar 25. PMID: 38523124.

Nene RV, Corbett B, Lambert G, Smith AM, LaFree A, Steinberg JA, Costantini TW. Identification and management of low-risk isolated traumatic brain injury patients initially treated at a rural level IV trauma center. *Am J Emerg Med.* 2024 Apr;78:127-131. doi: 10.1016/j.ajem.2024.01.014. Epub 2024 Jan 12. PMID: 38266433.

Geriatric

Ghneim M, Stein DM. Management of traumatic brain injury in older adults: What you need to know. *J Trauma Acute Care Surg.* 2023 Nov 1;95(5):780-789. doi: 10.1097/TA.00000000000004118. Epub 2023 Aug 17. PMID: 37590010.

Wycech Knight J, Fokin AA, Menzione N, Rabinowitz SR, Viitaniemi SA, Puente I. Are geriatric transfer patients with traumatic brain injury at risk for worse outcomes compared to non-geriatric? Propensity-matched study. *Brain Inj.* 2024 Jul 2;38(8):659-667. doi: 10.1080/02699052.2024.2337904. Epub 2024 Apr 3. PMID: 38568043.

Mower WR, Akie TE, Morizadeh N, Gupta M, Hendey GW, Wilson JL, Leonid Duvergne LP, Ma P, Krishna P, Rodriguez RM. Blunt Head Injury in the Elderly: Analysis of the NEXUS II Injury Cohort. *Ann Emerg Med.* 2024 May;83(5):457-466. doi: 10.1016/j.annemergmed.2024.01.003. Epub 2024 Feb 10. PMID: 38340132.

NeuroWorsening

Hawryluk GWJ, Aguilera S, Buki A, Bulger E, Citerio G, Cooper DJ, Arrastia RD, Diringer M, Figaji A, Gao G, Geocadin R, Ghajar J, Harris O, Hoffer A, Hutchinson P, Joseph M, Kitagawa R, Manley G, Mayer S, Menon DK, Meyfroidt G, Michael DB, Oddo M, Okonkwo D, Patel M, Robertson C, Rosenfeld JV, Rubiano AM, Sahuquillo J, Servadei F, Shutter L, Stein D, Stocchetti N, Taccone FS, Timmons S, Tsai E, Ullman JS, Vespa P, Videtta W, Wright DW, Zammit C, Chesnut RM. A management algorithm for patients with intracranial pressure monitoring: the Seattle International Severe Traumatic Brain Injury Consensus Conference (SIBICC). *Intensive Care Med.* 2019 Dec;45(12):1783-1794. doi: 10.1007/s00134-019-05805-9. Epub 2019 Oct 28. PMID: 31659383; PMCID: PMC6863785.

McCredie VA, Chavarría J, Baker AJ. How do we identify the crashing traumatic brain injury patient - the intensivist's view. *Curr Opin Crit Care.* 2021 Jun 1;27(3):320-327. doi: 10.1097/MCC.0000000000000825. PMID: 33852501; PMCID: PMC8240643.

Gallagher SP, Capacio BA, Rooney AS, Schaffer KB, Calvo RY, Sise CB, Krzyzaniak A, Sise MJ, Bansal V, Biffl WL, Martin MJ. Modified Brain Injury Guidelines for preinjury anticoagulation in traumatic brain injury: An opportunity to reduce health care resource utilization. *J Trauma Acute Care Surg*. 2024 Feb 1;96(2):240-246. doi: 10.1097/TA.0000000000004171. Epub 2023 Oct 24. PMID: 37872672.

Leddy, J. J. (2025). Sport-related concussion. *New England Journal of Medicine*, 392(5), 483-493.