Arkansas Trauma System Evidence-Based Guidelines for Diagnosis and Initial Treatment of Head Injury (Traumatic Brain Injury- TBI) in the Pre-hospital Setting

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Introduction-

Head injury continues to be one of the most common types of injury seen and treated in the Arkansas Trauma System. Swift in onset, but long on recovery, injury to the brain is also one of the most complex areas of trauma treatment today. Most importantly, the long-term outlook and disability from Traumatic Brain Injury (TBI) is primarily determined not just by the type and amount of energy afflicting the brain, but as importantly—by the initial and subsequent care of the patient in our trauma system. Proper identification of TBI along with proper care of the patient can prevent further damage from occurring. Expert and appropriate care of the patient with TBI begins in the field with our first responders and EMS partners, and continues along the way with initial stabilization, diagnosis in the ED, and subsequent hospital / outpatient care afterwards.

Initial Evaluation and Management-

Always assure the ABC's of trauma: airway, breathing, and circulation with a rapid, but careful primary assessment, that also includes a quick neurologic assessment (D) and exposure and examination (E) of the patient. This is important to detect and document the level of perfusion of the brain as well as quickly identify and correct any immediate life-threating conditions. [1] Stabilization of the head, spine, and extremities is important, and assessing the neurological function of the extremities is likewise essential to determine if any movement or action worsens the neurologic function of that limb or area of the body.

Glasgow Coma Scale (GSC) – Important measurement to use- and to measure correctly [Table 1]

The GSC was invented almost 50 years ago by Teasdale and Jennett [2] and has remained one of the key items to measure in patients with head trauma. However, many studies have shown that it is often mis-measured or neglected in the trauma patients. To properly perform a GCS

assessment, the patient is first observed and then verbally requested to move their arms, open their eyes, and to talk. If the verbal request, (or observation of a patient voluntarily talking and moving) doesn't reveal any effective motion, then some type of painful stimulus is the next test to try, in order to get a response. For instance, movement of the arms to painful stimuli across the midline (ex.- pinching the right arm with the patient moving their left arm to the pinched area) tells us that the patient has a motor GCS component of at least 5.

The severity and therefore the initial and follow-up assessment and management of TBI patients is typically graded using the GCS. We typically divide TBI patients into three main categories: [1, 3]

Minor head injury (including concussion)- ***GSC scores of 13-15*** represent mild head injury. The eye and verbal responses to the GCS scoring are more accurate predictors of TBI magnitude.

Moderate head injury- ***GSC scores of 9-12.***

Severe head injury- All patients with a ***GSC of <9.*** In severe TBI, the motor component is more predictive of extent of injury and recovery, than the eye and verbal response.

Table 1- Glasgow Coma Scale

Eye opening (E)	
None	1
To pressure	2
To sound	3
Spontaneous	4
Untestable	Reason:
Verbal response (V)	
None	1
Sounds	2
Words	3
Confused	4
Oriented	5
Untestable	Reason:
Motor response (M)	
None	1
Extension	2
Abnormal flexion	3
Normal flexion	4
Localizing	5
Obey commands	6
Untestable	Reason:

Pre-hospital Care of the TBI patient- the role of EMS

Care of the TBI patient typically involves rapid diagnosis as well as attention to stabilization of the patient. TBI injury can be made worse with hypoxia, shock, and poor perfusion of the brain from other causes, such as hemorrhage or edema. Thus, attention to the ABCs of trauma evaluation is critical as soon as EMS and first responders arrive at the scene of the accident. Decreased consciousness can mask underlying significant problems, and patients not able to talk and relate any neck or back pain should be assumed to have a spinal fracture. Therefore, appropriate precautions should be taken to stabilize and immobilize the spine during transport and in the ED handoff, until the spine can be cleared by appropriate x-rays or CT scans.

Both moderate and severe TBI patients may require advanced therapy along with neurosurgical consultation, and patients should be considered for rapid transfer to higher levels of trauma center. However, mild TBI can usually be management with close observation, along with care of other traumatic injuries at most Level III and IV hospitals.

EMS providers should always remember that one of their critical tasks is to prevent further brain injury by lack of proper ventilation and support of blood pressure. Mild TBI can be converted to moderate or severe TBI by the presence of hypoxia (PaO_2 <60 mmHg) and hypotension (systolic blood pressure [BP] <90 mmHg)—even of short duration. [3]

Thus, early intubation and resuscitation, as well as expeditious transfer to the most appropriate trauma center (not necessarily the closest non-trauma hospital) is key to prevent further injury to the brain. [1] In general, patients with a GCS of <9 need some type of airway control and ventilation, unless there is a short transport to the nearest appropriate trauma center. Intubation can be by traditional endotracheal intubation with rapid-sequence intubation—however, intubation using an oropharyngeal airway is also quite acceptable, especially if a difficult intubation is anticipated or rapid-sequence intubation is not easily achievable. [4] [5] Achievement of adequate oxygen and ventilation is the key goal, along with adequate perfusion, by any method. EMS providers should also remember that air transport from the field is not necessarily the best or quickest option for the patient to get to the most appropriate trauma center in the shortest time. [6] [7] Using ATCC to help coordinate movement and further care is always the wisest choice when dealing with TBI in the field.

A recent study of a state-wide EMS protocol for care of the TBI patient in Arizona showed with good training and protocols that survival to the hospital significantly improved, for severe TBI survival overall doubled and in patients with severe TBI requiring intubation, survival tripled. [8] Key strategies in this study were prevention of hyperventilation by use of End Title CO2 (ETCO2)

monitors, avoiding hypotension (<90 SBP), and checking for hypoglycemia as a cause of lowered GCS. [16]

Avoiding hypoxia, hyperventilation, and loss of airway control- For patients with a GCS <9, if they are not already intubated, should undergo rapid-sequence intubation. Just as in the EMS section, avoiding hyperventilation is critical to avoid further damage to the brain. Thus, ETCO2 and ABGs are important to measure right after intubation and serially to keep the PaCO2 between 35 and 45 mmHg. PaO2 should be kept >100 mmHg, and SaO2 > 95%. [1]

Avoiding hypotension (SBP <90)- For patients with hemorrhagic shock, a path of permissive hypotension is often times wise to follow until the patient can be taken to the OR for definitive hemorrhage control. However, for patients with moderate to severe TBI, maintaining the SBP >100 has been shown to reduce increased damage to the brain. [1]

Table 2, from the ACS TQIP program [1] outlines the recommended goals of vital signs and other measures in patients with TBI in the pre-hospital setting. Some tests (ABGs and INR, platelet count) are not typically available in the pre-hospital setting, but in cases of hospital to hospital transfers can and should be used to guide treatment and stabilization during transport:

Table 2. Goals of Treatment

Pulse Oximetry ≥ 95%	ICP 20 - 25 mmHg	Serum sodium 135-145
PaO_2 ≥ 100 mmHg	$PbtO_2$ ≥ 15 mmHg	INR ≤ 1.4
$PaCO_2$ 35-45 mmHg	CPP ≥ 60 mmHg *	Platelets ≥ 75 x 10^3 / mm^3
SBP ≥ 100 mmHg	Temperature 36.0-38°C	Hemoglobin ≥ 7 g/dl
PH 7.35-7.45	Glucose 80-180 mg/dL	

PaO2: partial pressure of oxygen; PaCO2: partial pressure of carbon dioxide; SBP: systolic blood pressure; ICP: intracranial pressure; PbtO2: brain tissue oxygen tension; CPP: cerebral perfusion pressure; INR: international normalized ratio; *depending on status of cerebral autoregulation

From: TQIP, ACS. "Best practices in the management of traumatic brain injury." ACS Committee on Trauma (2015): 3-23.

Other treatments and tests shown to provide benefit in the ED for patients with mild, moderate and severe TBI:

Tranexamic (TXA) -has been shown to benefit patients with TBI where there is intracranial bleeding, or a high risk of bleedings. The recent CRASH 3 study showed a survival benefit when TXA is given within 3 hours of the accident and showed benefit in mild to moderate TBI patients. This trial randomized patients with a GCS <13 or who had signs of intracranial bleeding on CT scan, showing good benefit with low side effects or complications. [9] Thus, while there may or may not be a benefit for the use of TXA in some patients with TBI (severe TBI), there seems to be little downside to giving it in the ED for most patients with TBI if there is any question as to intracerebral bleeding or in patients with moderate TBI (GCS between 9 and 13). TXA is given as a one gram dose over 10 minutes IV, followed by an additional one gram infused over 8 hours.

Treatments shown to NOT provide benefit in the pre-hospital setting for patients with mild, moderate and severe TBI: [4, 14]

As opposed to the recommendations above, there are several treatments, once popular, but now have not shown benefit and thus have fallen in favor:

Prophylactic hypothermia- there has been no benefit in severe TBI patients shown for early or short term cooling of the patient, while there may be other deleterious side-effects. Chilling the patient wastes precious time that should be devoted to rapid stabilization and transport, and can worsen existing hypocoagulation.

Hyperosmolar therapy for mild or moderate TBI- while using hypertonic saline and mannitol solutions have good theoretic advantages, there continues to be no proven benefit of using hypertonic saline or mannitol for mild to moderate TBI. Under controlled circumstances, using intracranial pressure monitoring, neurosurgical support, etc. there does seem to be some benefit for hyperosmolar therapy in the setting of severe TBI, but would not apply to the pre-hospital setting.

Steroids- Use of steroids for mild to moderate TBI has failed to show any benefit and is no longer recommended. Their use in severe TBI is contraindicated due to the side-effects and complications associated with administration.

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