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Head and Spinal Trauma Management in Disaster

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Abstract

Traumatic brain and spinal injuries are important causes of death and morbidity. Although trauma is a significant medical entity for mortality and morbidity in all age groups worldwide, it is a prominent cause of death and morbidity, especially under the age of 45. Apart from the main causes of multitrauma, natural disasters are also an important and devastating cause of mortality and morbidity and can present a major threat to individual and public health. Appropriate organization and implementation of trauma management should be performed in these scenarios as well to assure that a large-scale medical aid arrives to the scene.

Keywords: head trauma management, spinal trauma management, head and spinal trauma in disasters

Approaches to Head and Spinal Trauma in Multitrauma Patients

Traumatic brain and spinal injuries are important causes of death and morbidity. Although trauma is a significant medical entity for mortality, and morbidity in all age groups worldwide, it is a prominent cause of death and morbidity especially under the age of 45.[1]

Multitrauma is defined as 2 or more severe injuries in at least 2 separate areas of the body.[2,3] The most common causes of multitrauma are road traffic accidents, falls, penetrating injuries, assault injuries, and gunshot injuries.[4] Trauma-related deaths can be categorized into 3 time zones. The first zone is the deaths within seconds or minutes caused by massive vascular, cardiac, lung, or brain injuries. The second zone is the deaths within hours caused by bleeding into the third spaces, liver and spleen injuries, or pneumothorax which are not that massive to kill within the first seconds. The third zone is the deaths within days or weeks caused by secondary problems such as pulmonary embolism, sepsis, or organ failure. While first-zone deaths are a loss of life at the scene, there is no chance of medical intervention; preventive measures are more important at this stage. On the other hand, second-zone deaths can be prevented or reversible with medical intervention, so all trauma patients need to be evaluated systemically to maximize outcomes and reduce the risk of permanent sequelae.[4]

Apart from the main causes of multitrauma, natural disasters are also an important and devastating cause of mortality and morbidity and can present a major threat to individual and public health. Appropriate organization and implementation of trauma management should be performed in these scenarios as well to assure that a large-scale medical aid arrives to the scene.[5]

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Stages of Multitrauma Management

Preparation

A trauma patient needs to be approached and evaluated in the same organized manner by first aid attendants and trauma centers. To achieve this, first aid teams and a trauma transfer chain to the trauma centers must be organized in the medical healthcare systems. Professionals in first aid teams and trauma centers need to go through standardized education and training. Very well-established trauma centers with educated and equipped professionals need to be built. Trauma centers need to be well organized and equipped with modern medical instruments and facilities as well. The emergency response team (ERT) should notify the trauma center with the necessary information about the patient whenever possible.

Primary Evaluation

Studies show that the most effective initial emergency management is performed by local medical services since the rest's further proximity to the trauma scene in any case, like a road traffic accident or an earthquake.[6] The classic primary evaluation of advanced trauma life support (ATLS) is created in an organized order according to the injuries that pose the most immediate threats to life. This framework will be discussed in detail at separate parts of this special issue. Therefore, head and spinal trauma management in life support will be emphasized here.

After the ERT member secures himself or herself, the primary framework of basic life support consists of the following steps: airway, breathing, circulation assessment, disability assessment, and exposure (ABCDE).[7] In all blunt trauma patients, it has to be assumed that a cervical spine injury is present until proven otherwise. Therefore, during airway management, the cervical spine should be stabilized with a cervical collar. If a patient needs airway intervention, the anterior portion of the cervical collar can be removed, but in this situation, manual in-line stabilization should be done, since most displacements and luxations of the injured spine occur during the preintubation phase.[8,9] Once airway, breathing, and circulation conditions are assessed, a neurological exam (disability) should be done. The neurological exam should include a description of the patient's level of consciousness using the Glasgow Coma Scale (GCS) score and assessments of pupillary size and response to light, motor function, and sensation. One should note that any indication of a lateralizing sign could point to a potential head or spinal injury, and care should be taken accordingly. If a spinal injury is suspected, spinal immobilization and stabilization should be maintained with a trauma board.[7] Acute neurologic intervention, including imaging, medical, and surgical treatment, will be discussed in the following sections.

After that, the triage should be done according to the patient's need for treatment. Once this is achieved, the next step is the stabilization and safe transportation of the patient.

Prehospital Head Trauma Management

The purpose of the initial management of head trauma is to minimize secondary brain damage since primary brain damage cannot be reversed.[10]

Head injury is defined as any trauma to the head other than superficial injuries to the face. The prehospital management of suspected traumatic brain injury (TBI) begins with the primary survey of ATLS. Hypoxia and hypotension are most important causes of secondary brain damage; therefore, the patient should be monitored for blood oxygen levels and systolic and diastolic blood pressure. After that, medical performer should evaluate the level of consciousness of the patient using the GCS score (see Table 1). The GCS should be obtained by thorough interaction with the patient after ABC is assessed and prior to the administration of sedative or paralyzing agents, if possible.[11] The score should be used for following neurological state as well, but medical performer should be aware of the potential influences of several factors on the consciousness level other than TBI, such as sedating agents used prior to intubation, drugs, alcohol, or in disaster cases, malnutrition and homeostasis imbalance arising from many multiple organ problems.[12]

Third assessment is the pupil examination. The medical performer should note the evidence of orbital trauma, and left and right pupillary findings like light reflex and anisocoria should be identified. After identifying problems, treatment for airway, ventilation, oxygenation, and fluid resuscitation for hypotension should be done according to ATLS. If a cerebral herniation is suspected, hyperventilation (20 breaths per minute in an adult, 25 in a child, and 30 in an infant less than 1 year old) can be used as a temporizing measure.[11] One should always keep in mind that hyperventilation may cause iatrogenic secondary ischemia to brain.

Table 1. Glasgow Coma Scale for Adult and Pediatric Patients

	Adult Glasgow Coma Scale	Pediatric Glasgow Coma Scale
Eye opening		
4	Spontaneous	Spontaneous
3	Speech	Speech
2	Pain	Pain
1	None	None
Verbal response		
5	Oriented	Coss, Babbles
4	Confused	Irritable cries
3	Inappropriate	Cries to pain
2	Incomprehensive	Moans to pain
1	None	None
Motor response		
6	Obey command	Normal spontaneous movements
5	Localize the pain	Withdraws to touch
4	Flexor withdrawal	Withdraws to pain
3	Flexor posturing	Abnormal flexion
2	Extensor posturing	Abnormal extension
1	None	None

Table 2. European Federation of Neurological Society Traumatic Brain Injury Classification. For major and minor risk factors see Vos et al[15]

Classification	Characteristics		Indication of Immediate Head Computed Tomography
Mild		Hospital admission GCS score = 13 to 15 Loss of consciousness if 30 min or less	
	Category 1	GCS: 15 No risk factors or only 1 minor risk factor present (CHIP rule) Head injury, no TBI	No
	Category 2	GCS = 15 With risk factors: >1 major risk factor(s) or >2 minor risk factors (CHIP rule)	Yes
	Category 3	Yes	
Moderate	GCS = 9-12		Yes
Severe	GCS equal or less than 8		Yes
Critical	GCS = 3-4, with loss of pupillary reactions and absent or decerebrate motor reactions		Yes

GCS: Glascow Coma Scale, TBI: Traumatic Brain Injury, CHIP: Computed Tomography in Head Injury Patients.

- Patients with MTBI who have a normal neurological examination (including a GCS = 15), no risk factors and a normal CT can be observed at home. The patient can be admitted if some extracerebral cause like chest or abdomen trauma occurred.
- Due to delayed cerebral swelling, children under 6 years of age who are discharged home from the emergency department, head injury warning instructions should be given to the family.
- Patients with a new and clinically significant traumatic lesion on CT, GCS <15, focal neurological deficit, restlessness or agitation, intoxication with alcohol or drugs, or other extracranial injuries should be admitted to the hospital.
- A repeated CT-scan should be considered if the admission CT findings are abnormal or if risk factors are present.
- All patients with a GCS <15, including risk factors should be admitted to hospital for observation.
- A complete neurological examination is mandatory after admission and should include assessment of the GCS, pupillary size and reaction to light, and short-term memory. Repeat neurological examination should be carried out, its frequency being dependent on the clinical condition of the patient.
- In-hospital observation of patients with a head injury should be conducted by professionals competent in the assessment of head trauma.
- All patients with MTBI who have been admitted to the hospital for observation should be seen at least once, after 2 weeks of discharge.

Figure 1. European Federation of Neurological Society's treatment management recommendations for mild traumatic brain injury.

- Decompressive craniectomy (DC); Bifrontal DC is not recommended to improve outcomes at 6 months post-injury in severe TBI patients and with ICP elevation to values >20 mm Hg for more than 15 minutes within a 1-hour period that are refractory to first-tier therapies. However, this procedure has been demonstrated to reduce ICP and to minimize days in the intensive care unit (ICU). A large frontotemporoparietal DC (not less than 12 x 15 cm or 15 cm diameter) is recommended over a small frontotemporoparietal DC for reduced mortality and improved neurologic outcomes in patients with severe TBI.
- Prophylactic hypothermia is not recommended since it is not found effective.
- There is insufficient data about hyperosmolar therapy's effects.
- Cerebrospinal Fluid Drainage: An external ventricular drainage (EVD) system adjusted to zero at the midbrain with continuous drainage of CSF may be considered to lower intracranial pressure (ICP) burden more effectively than intermittent use. Use of CSF drainage to lower ICP in patients with an initial Glasgow Coma Scale (GCS) <6 during the first 12 hours after injury may be considered.
- Ventilation therapies as prolonged prophylactic hyperventilation is not recommended.
- Anesthetics, Analgesics, and Sedatives; Administration of barbiturates is not recommended. High-dose barbiturate administration is recommended to control elevated ICP refractory to maximum standard medical and surgical treatment. During barbiturate therapy hemodynamic stability is needed. Although propofol is recommended for the control of ICP, it is not recommended for improvement in mortality or 6-month outcomes. Caution is required as high dose propofol can produce significant morbidity.
- Steroids are not recommended for improving outcome or reducing ICP. In patients with severe TBI, high-dose methylprednisolone was associated with increased mortality and is contraindicated.
- Nutrition: Feeding patients to attain basal caloric replacement at least by the fifth day and, at most, by the seventh day post-injury is recommended to decrease mortality and transgastric jejunal feeding is recommended to reduce the incidence of ventilator associated pneumonia.
- Infection Prophylaxis: Antimicrobial-impregnated catheters may be considered to prevent catheter-related infections during EVD. To prevent ventilator-associated infections, early tracheostomy should be considered.
- Deep Vein Thrombosis Prophylaxis: Low molecular weight heparin (LMWH) or low-dose unfractionated heparin may be used in combination with mechanical prophylaxis, but caution should be exercised in terms of intracranial hemorrhage.
- Seizure Prophylaxis: Prophylactic use of antiseizure medication is not recommended.
- Intracranial Pressure Monitoring: Management of severe TBI patients using information from ICP monitoring is recommended.
- Cerebral Perfusion Pressure (CPP) Monitoring; Management of severe TBI patients using guidelines-based recommendations for CPP monitoring is recommended.
- Advanced Cerebral Monitoring: Jugular bulb monitoring of arteriovenous oxygen content difference (AVDO2), as a source of information for management decisions, may be considered if possible.
- Blood Pressure Thresholds: Maintaining SBP at ≥100 mm Hg for patients 50 to 69 years old or at ≥110 mm Hg or above for patients 15 to 49 or over 70 years old may be considered to decrease mortality and morbidity.
- Intracranial Pressure Thresholds: Treating ICP above 22 mm Hg is recommended because values above this level are associated with increased mortality. A combination of ICP values and clinical and brain CT findings may be used to make management decisions.
- Cerebral Perfusion Pressure Thresholds: The recommended target cerebral perfusion pressure (CPP) value for survival and favorable outcomes is between 60- and 70-mm Hg.
- Advanced Cerebral Monitoring Thresholds: Jugular venous saturation of <50% may be a threshold to avoid reducing mortality and improve outcomes.

Figure 2. Brain Trauma Foundation's management guidelines for a severe traumatic brain injury.

Lastly, in ATLS, a patient should be transported to a trauma center as quickly as possible. A patient with a TBI should be transported to a facility with CT scanning, neurosurgical care, and the ability to monitor intracranial pressure (ICP) and treat intracranial hypertension. However, in disasters like an earthquake, achieving this organization remains a significant challenge because of the poor conditions of the disaster area. Therefore, the rapid establishment of outdoor medical camps for patient care and resuscitation is mandatory within a short period of time if a medical transportation corridor is not available at the time.[5]

- An epidural hematoma (EDH) greater than 30 cm3 should be surgically evacuated regardless of the patient's clinical status. An EDH less than 30 cm3 and with less than a 15-mm thickness and with less than a 5-mm midline shift (MLS) in patients with a GCS score greater than 8 without focal deficit can be observed with serial CT scanning and close neurological observation in a neurosurgical center. If the patient has a surgical indication, surgery should be performed immediately.
- Acute Subdural Hematomas: An acute subdural hematoma (SDH) with a thickness greater than 10 mm or a MLS greater than 5 mm on CT scan should be surgically evacuated, regardless of the patient's clinical status. All patients with acute SDH in coma (GCS score less than 9) should undergo ICP monitoring. A comatose patient (GCS score less than 9) with an SDH less than 10-mm thick and an MLS less than 5mm should undergo surgical evacuation of the lesion if the GCS decreased between the time of injury and hospital admission by 2 or more points and/or the patient presents with asymmetric or fixed and dilated pupils and/or the ICP exceeds 20 mm Hg. If the patient has a surgical indication, surgery should be performed immediately.
- Traumatic Parenchymal Lesions: Patients with parenchymal mass lesions and progressive neurological deterioration, medically refractory intracranial hypertension, or signs of mass effect on CT scan should be surgically treated. Patients with parenchymal mass lesions but with no significant mass effect on CT and without neurological deterioration, have controlled ICP, can be observed with intensive monitoring and serial imaging. Bifrontal DC within 48 hours of injury is a treatment option for patients with diffuse, medically refractory posttraumatic cerebral edema and resultant intracranial hypertension. Decompressive procedures, including subtemporal decompression, temporal lobectomy, and hemispheric decompressive craniectomy, are other surgical treatment options for patients with refractory intracranial hypertension and diffuse parenchymal injury with clinical and radiographic evidence for impending transtentorial herniation.
- Posterior Fossa Mass Lesions: Patients with mass effect on CT scan or with neurological dysfunction or deterioration should be surgically treated. Patients with lesions and no significant mass effect on CT scan and without signs of neurological dysfunction may be closely observed with serial imaging. If the patient has a surgical indication, surgery should be performed immediately.
- Depressed Cranial Fractures: Patients with open (compound) cranial fractures depressed greater than the thickness of the cranium should be surgically treated because of the risk of infection. Patients with open (compound) depressed cranial fractures may be treated medically if there is no clinical or radiographic evidence of dural penetration, significant intracranial hematoma, depression greater than 1 cm, frontal sinus involvement, gross cosmetic deformity, wound infection, pneumocephalus, or gross wound contamination. Nonoperative management of closed (simple) depressed cranial fractures is a treatment option. To reduce the incidence of infection, early operation and antibiotic prophylaxis are recommended.

Figure 3. Brain Trauma Foundation's recommendations for surgical management of traumatic brain injury.

Assessment of Head Trauma in the Emergency Medical Department

The priority for all emergency department patients is the stabilization of the airway, breathing, and circulation. If a depressed

Table 3. American Spinal Injury Association Impairment Scale and Description of Associated Deficits

ASIA A: Complete	No sensory or motor function is preserved in the sacral segments S4-5.
ASIA B: Sensory Incomplete	Sensory, but not motor function, is preserved below the neurological level and includes the sacral segments S4-S5 (light touch or pin prick at S4-S5 or deep anal pressure), and no motor function is preserved more than three levels below the motor level on either side of the body.
ASIA C: Motor Incomplete	Motor function is preserved at the most caudal sacral segments for voluntary anal contraction, or the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments S4-S5 by light touch, pinprick, or deep anal pressure) and has some sparing of motor function more than 3 levels below the ipsilateral motor level on either side of the body. (This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C, less than half of key muscle functions below the single NLI have a muscle grade ≥3.
ASIA D: Motor Incomplete	Motor incomplete status as defined above, with at least half (or more) of key muscle functions below the single NLI having a muscle grade ≥3.
ASIA E: Normal	If sensation and motor function, as tested with the ISNCSCI, are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.
ND	For documentation of the sensory motor and NLIlevels, the ASIA-AIS, and/or the zone of partial preservation when they cannot be determined from examination results

ASIA, American Spinal Injury Association Impairment Scale; AIS, ASIA Impairment Scale; ISNCSCI, International Standards for Neurological Classification of Spinal Cord Injury; ND, not determinable; NLI, neurological level of injury.

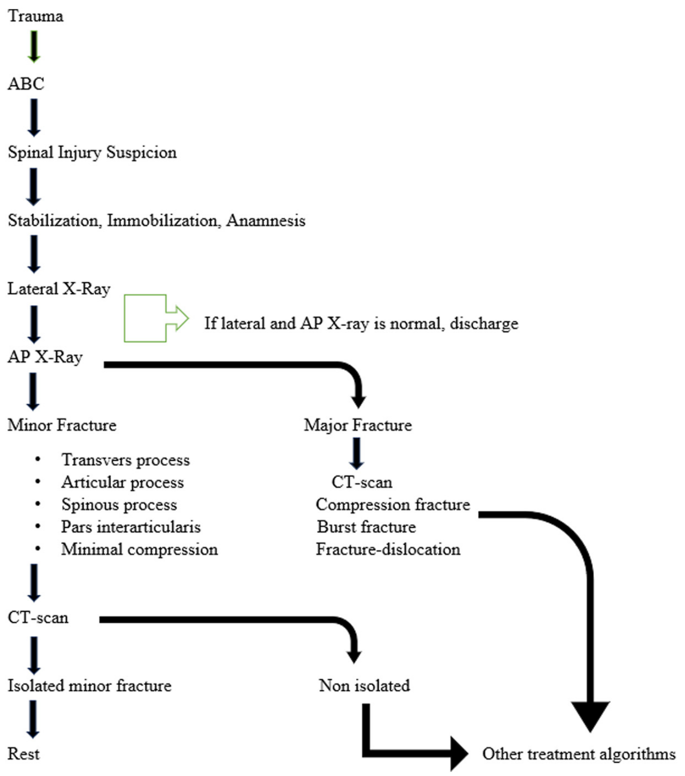

Figure 4. First examination in spinal trauma.

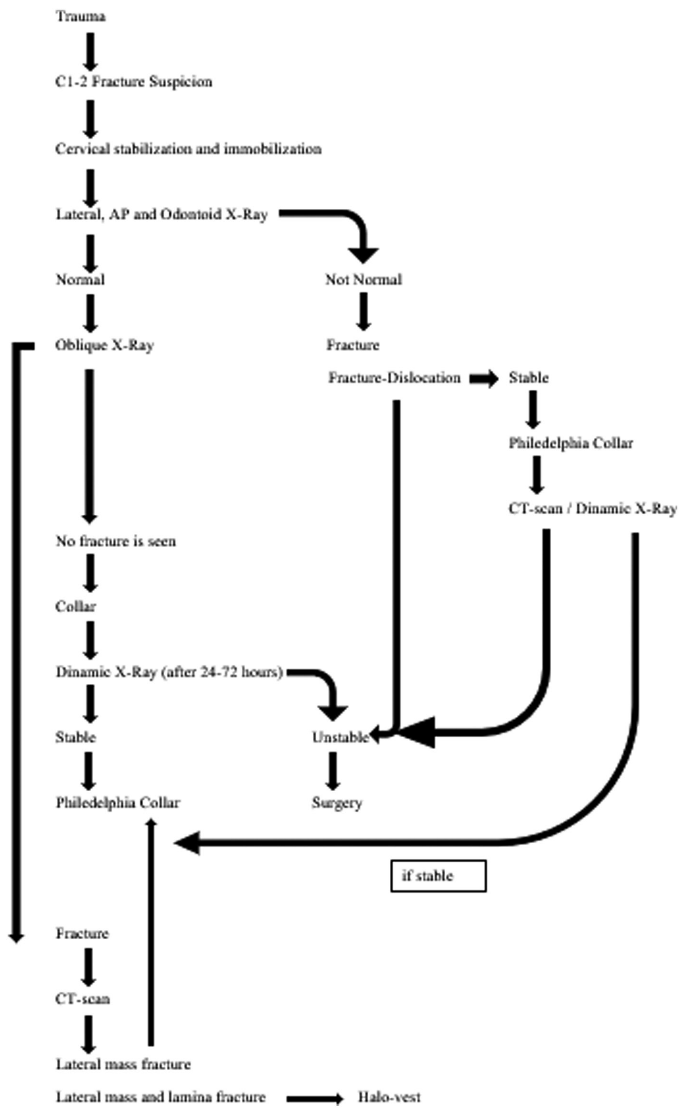

Figure 5. Treatment algorithm if there is suspicion for a C1-C2 fracture.

conscious level is apparent, medical performer should consider brain injury until proven otherwise. If possible, a whole history of the patient with previous diseases, drug use, and family history should be taken, and a whole physical examination with a neurological examination should be done. If a TBI or spinal injury is suspected, this should be further assessed by a trained member or staff in neurosurgery if possible. This assessment should include the clinical importance of the injury as a high or low risk. The imaging should be done according to the risk profile of these injuries or to the risk factors indicating a possible brain or spinal injury.

Many guidelines suggest performing a computerized tomography (CT) head scan as quickly as possible if there are following risk factors:[13,14]

- If on initial assessment, GCS is less than 13.
- Two hours after the injury, GCS is less than 15.
- There is a suspicion of an open or depressed skull fracture.
- There is a sign of skull base fracture like a hemotympanum, "racoon" eyes, cerebrospinal fluid (CSF) leakage from the ear or nose, or Battle's sign.
- The patient had a posttraumatic seizure or amnesia.
- The patient had vomited more than once.
- The patient has a focal neurologic deficit.
- The patient has a severe headache that continues despite the medical treatment.
- There is a history of anticoagulant drug use or coagulation disorders.
- The trauma to the patient was with high energy.
- If the patient is a child and has a tense fontanelle; posttraumatic amnesia; a large bruise, swelling, or laceration on the head, these should be assessed as risk factors as well.

Medical performer can assess the severity of the traumatic brain injury according to the GCS score as well. There is a general agreement among physicians that TBI is classified as mild, moderate, or severe. GCS scores of 14 and 15 are accepted as mild, GCS scores between 9 and 13 are accepted as moderate, and GCS scores under 9 are accepted as severe. Usually, there are much more modifications to this classification in the literature. The importance of the severity classifications of TBI lies in the management of treatment choice. The European Federation of Neurological Society (EFNS) Task Force recommends a TBI classification using the GCS score and risk factors as shown in Table 2.[15]

In a mild or moderate TBI, a performed CT-head scan may show the underlying pathology, and treatment can be done accordingly. EFNS' treatment management for mild TBI (MTBI) recommendations are shown in Figure 1.[15]

In the case of a severe TBI, the Brain Trauma Foundation's management guidelines regarding 11 treatment models are shown in Figure 2. The guidelines address treatment interventions, monitoring, and treatment thresholds that are particular to TBI or that address a risk that is higher in TBI patients.[16]

Brain Trauma Foundation's recommendations for the surgical management of TBI are shown in Figure 3.[17]

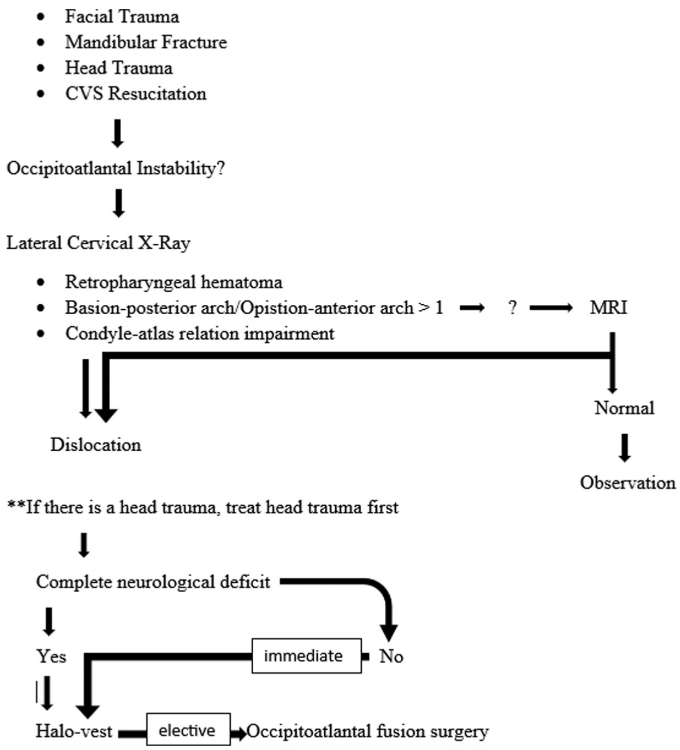

Figure 6. Treatment algorithm if there is suspicion for occipitoatlantal trauma.

Prehospital Spinal Trauma Management

If a spinal trauma or spinal injury is suspected, spinal motion restriction should be maintained with a backboard, scoop stretcher, vacuum splint, ambulance cot, or other similar devices. In the case of an unstable spinal injury, patient transportation poses a risk of a displacement; therefore, medical performers in prehospital management should minimize unnecessary movements during transportation.[18] Prehospital multitrauma management should be applied for spinal trauma as well.

Assessment of Spinal Trauma in Emergency Medical Department

During the primary survey of ATLS in disability evaluation, after assessing the GCS score and pupillary size and response, the medical performer should assess the motor function and reflexes in the extremities, and one should identify any lateralizing sign since it can be an indication of TBI and spinal cord injury (SCI). A motor deficit with a sensory deficit, bladder or bowel disfunction, and priapism in males can be a sign of SCI in a trauma patient. In a high-level SCI, tachypnea and diaphragmatic breathing can be subtle signs as well. When a circulatory shock is present and it cannot be explained by hypovolemia or bleeding, a neurogenic shock associated with SCI can be a sign of SCI as well, especially with bradycardia. After the primary survey is done, the medical performer should obtain a full and detailed history and physical examination of the patient. When a SCI is suspected, the level of injury should be identified as rapidly as possible. The American Spinal Injury Association (ASIA) Impairment Scale (AIS) is the most commonly used tool for SCI level identification (see Table 3)

After initial management, if a SCI or spinal trauma is suspected, a spinal CT scan should be obtained.

There are several spinal trauma classification systems, like the Subaxial Cervical Injury Classification System, the Thoracolumbar Injury Classification System, and the AO Spine Trauma Classification. These systems use CT, x-ray, magnetic resonance imaging and physical examination findings, and patients' scores from these classification systems are used to guide decision-making regarding surgery or nonsurgical treatment.

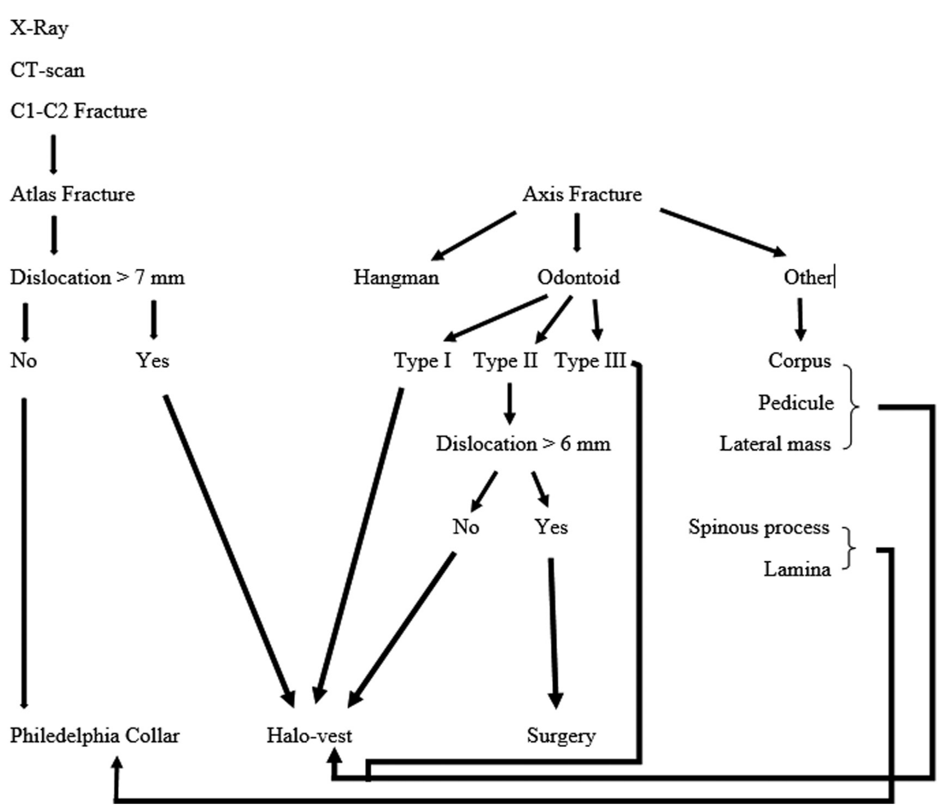

Figure 7. Treatment algorithm in C1-C2 fractures.

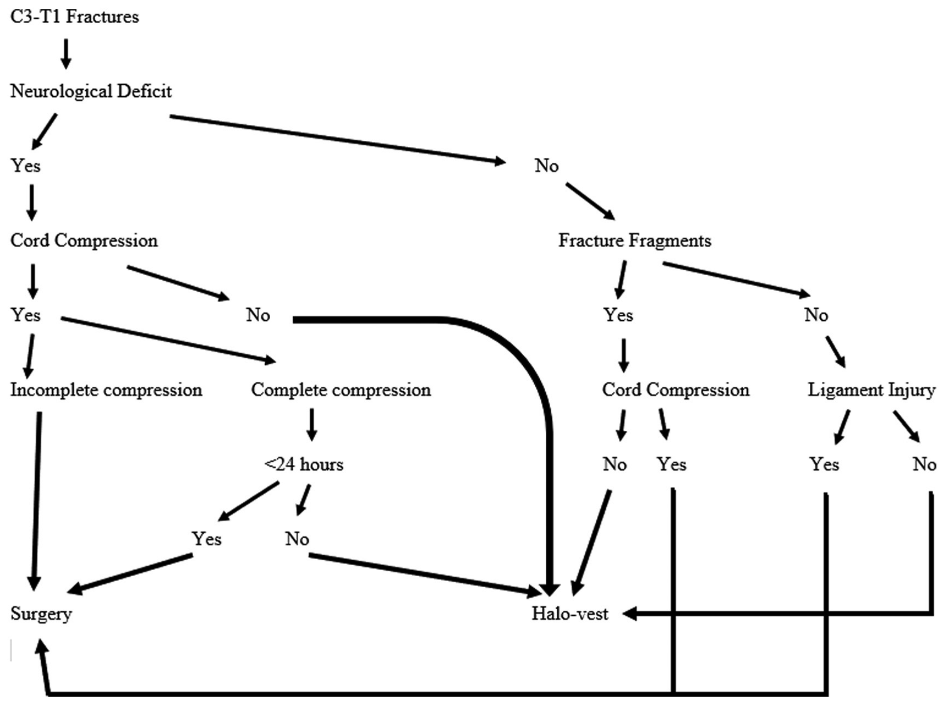

Figure 8. Treatment algorithm for C3-T1 fractures.

Our Institutional Neurosurgery Department's treatment algorithms for spinal trauma are shown in figures, respectively.

In case of a spinal injury suspicion, after the ABC of first aid, the patient should be put on a neck brace and trauma board and then transferred to a spinal trauma center. A whole neurological examination should be performed, and the bilateral anteroposterior and lateral x-rays of the whole spinal column should be taken. According to the neurological exam and x-ray findings, a CT scan can be taken as well. If there is an isolated minor fracture, rest and an orthosis would be recommended, depending on the fracture severity and level. If there is a major fracture, other treatment models should be evaluated (see Figure 4).

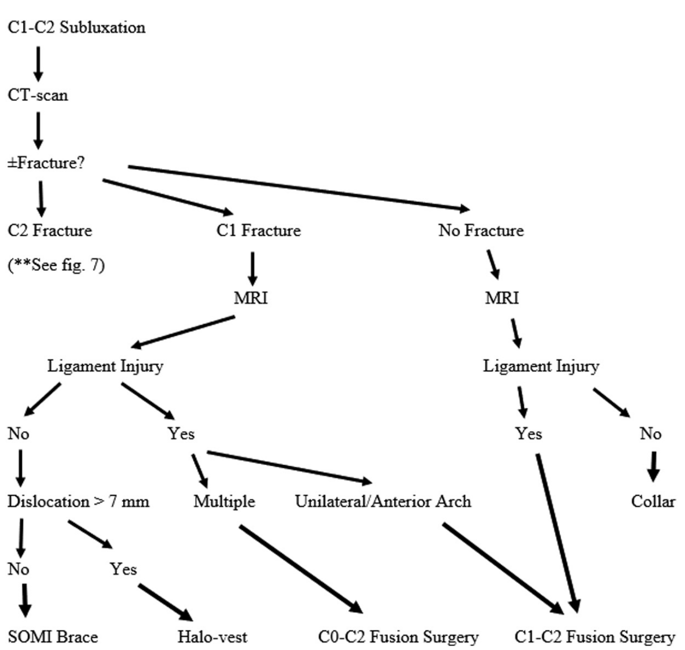

Figure 9. Treatment algorithm in C1-C2 subluxation.

If there is suspicion for a C1-C2 fracture, the treatment algorithm is shown in Figure 5.

In spinal trauma, occipitoatlantal instability should be suspected in combination with head trauma, facial trauma, mandibular fracture, and CVS resuscitation. The treatment algorithm is shown in Figure 6.

In atlas fractures, if the lateral mass of C1 is dislocated more than 7 mm lateral to the lateral mass of C2, there is a risk of instability. Conservative treatment such as immobilization with a halo vest is recommended in most of the cases. Axis fractures are treated depending on the fractured part of the axis. Conservative treatment such as immobilization with halo vest is recommended in most of the cases. If there is just a corpus, pedicule, or lateral mass fracture, a collar is enough for the fusion. If there is an odontoid type II fracture where the odontoid process is dislocated more than 6 mm, surgery is indicated (see Figure 7).

The prime surgery indication for C3-T1 fractures is cord compression. If there is no cord compression, conservative treatment such as immobilization with a halo vest is recommended (see Figure 8).

If there is a suspicion of a C1-C2 subluxation, the treatment algorithm shown in Figure 9 is recommended.

In the case of a burst fracture, the neurological function level should be evaluated according to the ASIA impairment scale. If the neurological exam is normal (ASIA grade E), surgery indications in burst fractures are that the initial kyphosis is more than 20% or anterior corpus height loss is more than 50%. If there is a neurological deficit (ASIA grades A, B, C, D), decompression surgery is indicated. Different surgical treatment options are available depending on the compression site of the spinal cord (see Figure 10).

Surgery indications for compression fractures are that the initial kyphosis is more than 30% or the anterior corpus height loss is more than 50%. If there is no posterior ligament injury, posterior spinal fusion is recommended. If there is a posterior ligament injury, anterior spinal fusion is recommended (see Figure 11).

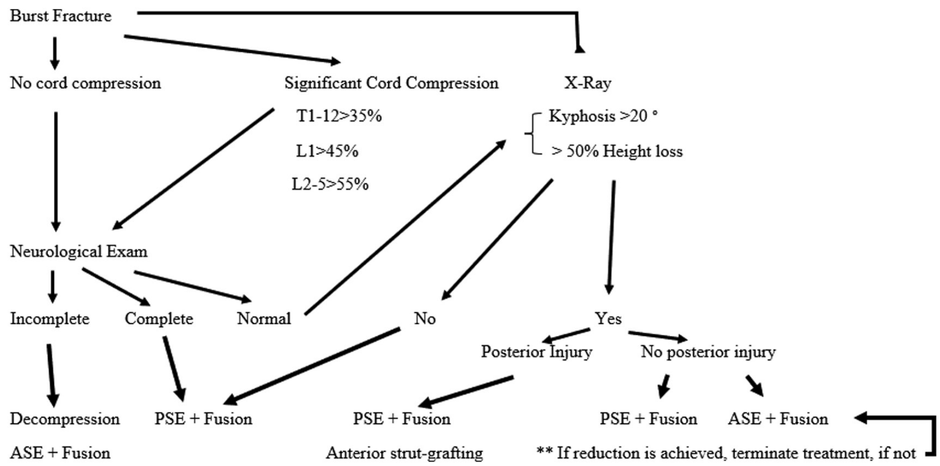

Figure 10. Treatment algorithm in burst fractures. ASE, anterior spinal instrumentation; PSE, posterior spinal instrumentation.

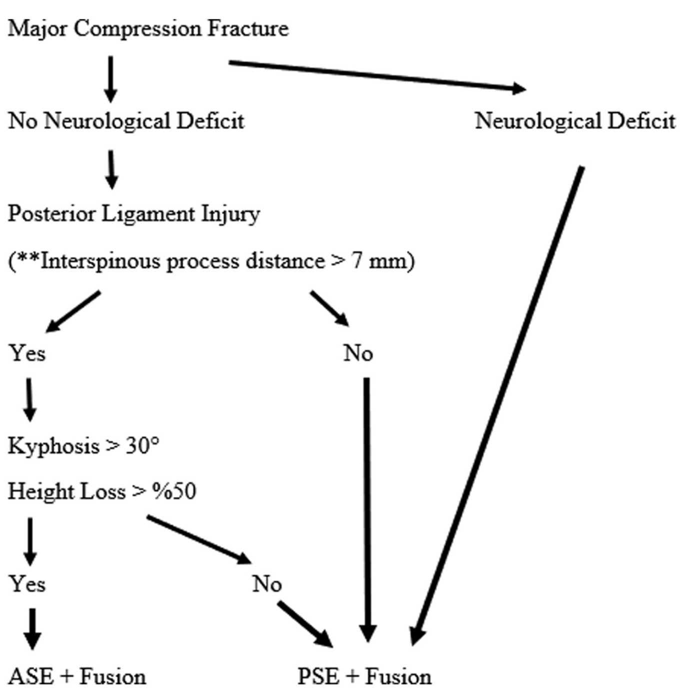

Figure 11. Treatment algorithms in major compression fractures. ASE, anterior spinal instrumentation; PSE, posterior spinal instrumentation.

Fracture–dislocation is more common with high-energy trauma, and the possibility of a neurological deficit is high. If there are posterior facet disclocation, rotational instability, or translational strain, posterior segmental reduction is recommended at first, and then fusion surgeries must be performed. If there is cord compression, posterior cord decompression surgery is indicated with the use of orthotic prosthesis for 3 months posteroperatively (see Figure 12).

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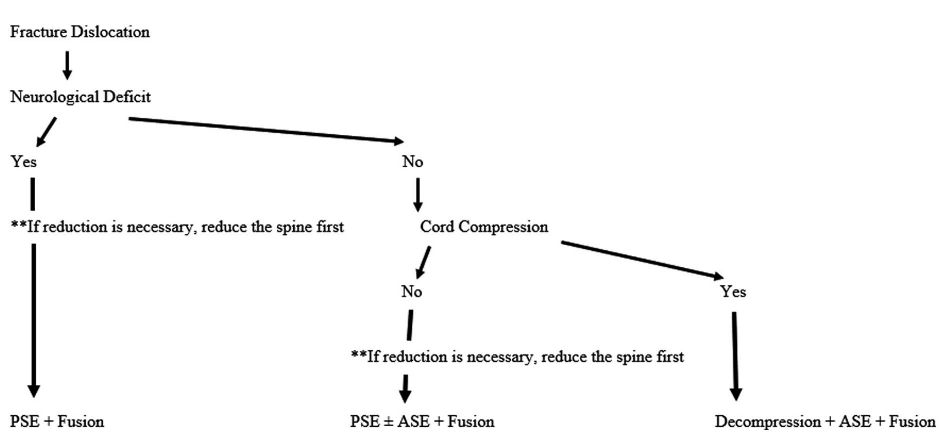

Figure 12. Treatment algorithm in fracture–dislocation. ASE, anterior spinal instrumentation; PSE, posterior spinal instrumentation.

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