



Review

Management of Pediatric Severe Head Trauma

Çağatay Önal

Inonu University School of Medicine Department of Neurosurgery, Malatya, Turkey

Abstract

The management of a child with severe traumatic brain injury requires multidisciplinary approach. Maintenance of a secure airway, stabilization of breathing and circulation are essential. After the emergent interventions, the management should be focused on optimizing the brain perfusion, establishing the metabolic balance, and prevention of cerebral edema. Besides the neurological state, laboratory information and radiological findings should closely be followed-up. Unfortunately, literature data focusing on pediatric severe traumatic brain injury is still limited.

Keywords: brain, child, head, injury, trauma

Corresponding Address: Çağatay Önal, M.D., Inonu University School of Medicine Department of Neurosurgery, Malatya, Turkey.

E-mail: conal_tr@yahoo.com

The recent therapy of pediatric severe head trauma focuses on the maintenance of optimal metabolic conditions by providing adequate substrates to the cerebral tissue, preserving the brain from herniation syndromes and secondary insults due to trauma. Traumatic brain injury (TBI) in this age group consists the major reason of morbidity and mortality. Statistical data from the United States report a head trauma incidence for every fifteen seconds, and a death for every twelve minutes. The incidence for head trauma is about 200 / 100000 and the number of morbid patients with prolonged hospitalization per year is about 15000. Annual death due to head trauma is reported to be 3000 – 4000 [1].

Primary care of a trauma patient involves the maintenance of airway and control of respiration and circulation. The probability of cervical injury in the patients with a trauma level above supraclavicular region is significant. There is also an important risk of airway obstruction due to relatively big size of tongue and short and narrow constitution of epiglottis in pediatric population. The security of airway is mainly based on S-O-A-P which is suction (S), oxygenation (O), airway maintenance (A), and pharmacology (P). Suction should be performed by a mechanism which has a vacuum power of at least 300 mm Hg and an aspiration capacity of 30 liters / minute. An effort of %100 oxygen ventilation by mask in preintubation period permits total discharge of nitrogen from functional residual capacity which results in the optimum alveolar oxygenation. Those applications which cause obstruction of venous return due to cervical compression in fixation of airway passage should also be avoided [2].

The assisted ventilation indications in head trauma involves a Glasgow Coma Score (GCS) of 10 or less, 3 points or more decrease in GCS independent of admission score, anisocoria greater than 1 mm, concomitant cervical spinal cord injury, apnea, hypercarbia (paCO₂ more than 45 mm Hg), loss of pharyngeal reflex, and spontaneous hyperventilation (paCO₂ 25 mm or less). The gold standard for airway control in pediatric population is orotracheal intubation under direct vision. Nasotracheal intubation should be avoided in those children with severe head injury [3,4].

The ideal orotracheal intubation in a severely head injured patient is a two person process with one stabilizing the probably injured cervical spine while the other maintains the secure airway by intubation under direct vision. Even though, a normal lateral x-ray of cervical spine

is a calming and comforting issue for the physician, it should be emphasized that it does not totally exclude a cervical traumatic pathology [1] .

Rapid sequence intubation is a more secure procedure compared to the orotracheal intubation performed with no neuromuscular blockage. It may be applied to emergent cases with no previous preparation having the risk of gastric content aspiration. It involves the stages of preparation, preoxygenation, sedation, neuromuscular blockage, and orotracheal intubation. Adequate medication which will prevent the morbidity related to hypotension, hypoxemia, intracranial hypertension, and gastric content aspiration is instituted. Lidocaine, phentanyl, and vecuronium compose a secure and effective combination in hemodynamically unstable patients who require rapid sequence intubation. In those patients who are hemodynamically stable, an additional rapid acting benzodiazepine (midazolam) may successfully be added to this combination. Another alternative for the hemodynamically stable head injured patient is thiopental. Brain oxygen metabolism is decreased by 50 percent within fifteen minutes after the intravenous administration of this agent. Excretion time is similarly fast as the effect time which is indicative for an additional sedative – analgesic medication in practical use [2].

The cardiac rate, blood pressure, the pulse quality in central and peripheral regions, skin and brain perfusion constitute the main points of circulatory evaluation in posttraumatic patients. Posttraumatic hypoperfusion may be related to hypovolemia (hemorrhage) or cardiac contusion. Cardiac contusion is quite rare in pediatric population compared to the adults. The choice in the resuscitation fluid should be isotonic crystalloid (20 ml/kg) (0.9 NaCl). Hypotonic fluids should never be used in emergent resuscitation of brain injured patient. Maintenance fluid therapy should be based on isotonic crystalloids, colloids, or packed red cells [2].

Computerized tomography(CT) has an indisputable place in diagnosis and therapy of neurointensive care patients. It is known that 15% of adult patients with severe head trauma exhibit aberrant intracranial hypertensive symptoms despite a normal brain CT. Magnetic resonance imaging (MRI) is a superior method of investigation in the management of head injury where conventional brain CT is insufficient. It has a specific role in identification of brain edema in diffusion weighted sequences and in evaluation of cerebral blood flow with special neuroimaging techniques. The correlation of magnetic resonance spectroscopy (MRS) and functional MRI with conventional MRI sequences may yield very significant information

on the response of neural tissue against traumatic processes. The disadvantages related to this superior instrument may be the difficulties of transportation of the severely injured patient with very many vital attachments – some with metallic components which are incompatible with the technique- longer investigation periods compared to CT and financially high profile [3,5].

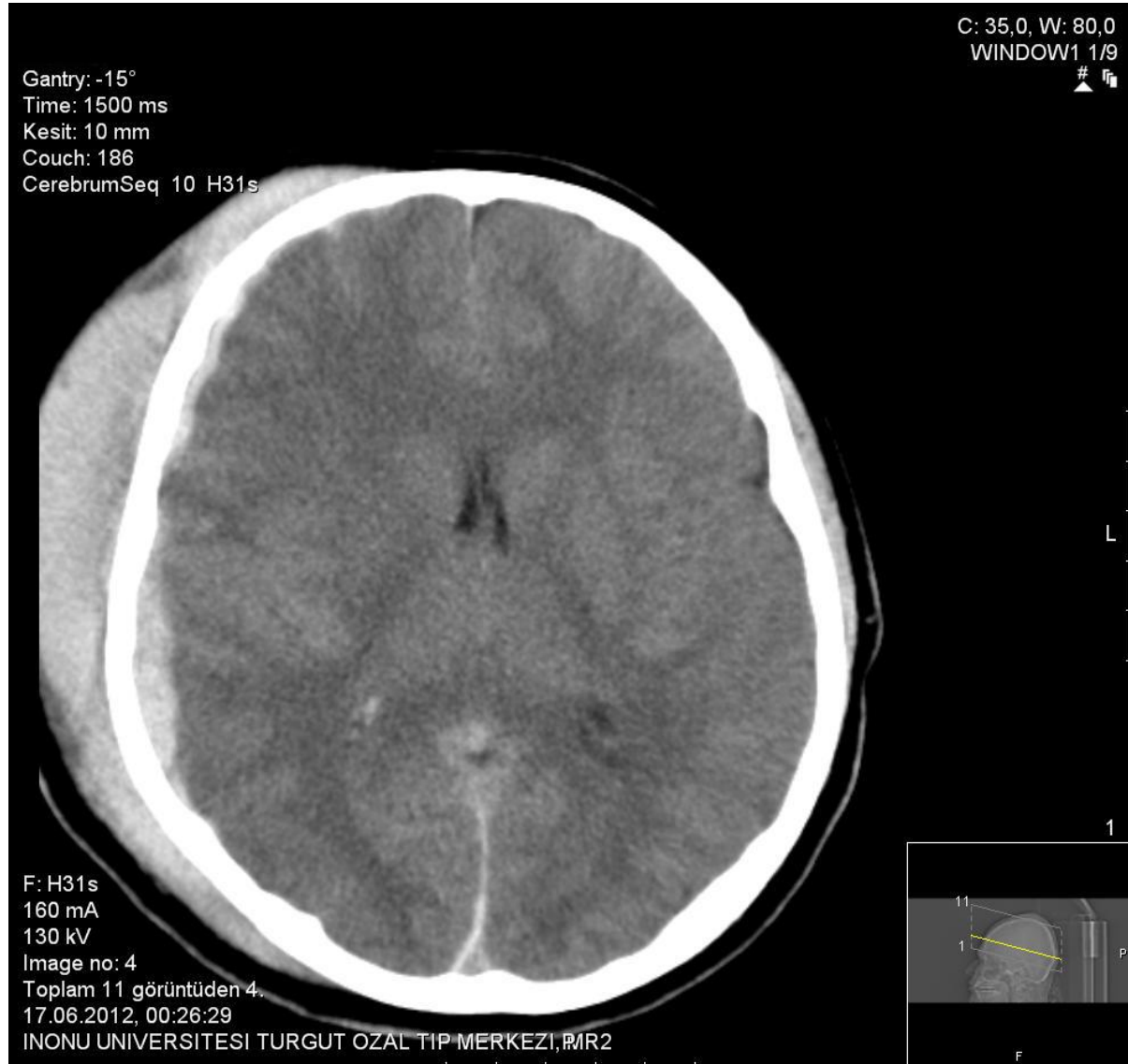


Figure 1: Axial CT of a 16 year old boy after a traffic accident revealing right frontoparietal scalp hematoma, diffuse cerebral edema, traumatic subarachnoid hemorrhage, right frontoparietal subdural hematoma

Figure 2A:

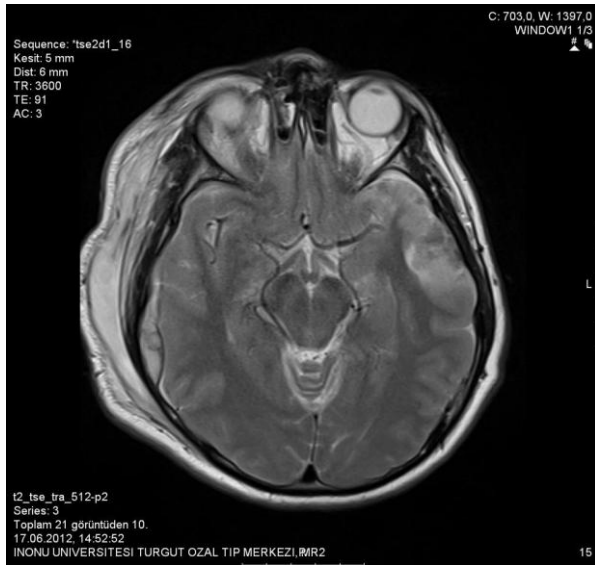


Figure 2B



Figure 2C:



Figure 2A,B,C: Axial, sagittal and coronal MR images of the same patient disclosing the previously explained traumatic lesions and multiple contusion areas

Intracranial neuromonitorization relies on the fact of predicting the development of intracranial hypertensive process before herniation symptoms appear. The purpose is to maintain an effective cerebral perfusion pressure. Guidelines for the Management of Severe Head Injury state that the patients harboring abnormal cranial CT with GCS of 3-8, and patients having normal cranial CT findings but exhibiting abnormal motor posture or hypotension should be neuromonitorized. These criteria which are adequate for adults are thought to be also relevant for pediatric population. Increased intracranial pressure is correlated with unfavourable prognosis. The pros and cons for intracranial neuromonitorization should also be evaluated regarding clinical characteristics of each specific case e.g. the presence or absence of coagulopathy etc. Intracranial pressure monitorization using a ventricular catheter is the most precise, reliable, and feasible method of evaluation. This method also gives the chance of cerebrospinal fluid drainage. Parenchymal fiberoptic and microtransducer systems are also credible. Subarachnoid, subdural, and epidural monitorization systems have a higher tendency of inaccuracy [2,6].

The principal methods of cerebral blood flow evaluation are stable Xe CT, radioactive Xe tests and transcranial doppler applications. Stable Xe CT discloses the regional blood flow variations related to the anatomical injury. Radioactive Xe tests either with inhalation or injection give informative data about regional blood flow with the aid of detectors. They can be applied to dynamic studies. The major drawback of the method is the lack of correlation between the blood flow and anatomical injury. Transcranial doppler application is very limited in children. It can alert the clinician about an unfavourable brain perfusion state. It measures velocity rather than flow and is mainly applicable in the territory of middle cerebral artery [7].

Different methods can be utilized for the assessment of brain metabolism. Jugular venous saturation values are widely used in adults for evaluation of oxygen transportation to the brain. Barbiturate or hyperventilation treatments can be adjusted according to these parameters. Near-infrared spectroscopy is a method based on the assessment of the oxidative states of cytochromes in brain injured patients in order to regulate the therapy. It is used to evaluate the metabolic states in pediatric head trauma and neonatal hypoxic – ischaemic brain. Positron emission tomography (PET) is an investigation of longer duration and despite the

risks of transportation in the hospital, the metabolic maps performed after brain trauma usually give important hints about brain glucose consumption [7].

After the performance of emergent resuscitation procedures and surgical interventions in a head trauma patient, management in neurointensive care unit should focus on maintenance of physiological stability and prevention of increased intracranial pressure. To reach an efficient perfusion pressure level plays a key role in avoidance of secondary ischaemic brain injury. According to the Guidelines for the Management of Severe Traumatic Brain Injury, the minimum value for a secure brain perfusion pressure should be 70 mm Hg in adults. It is difficult to assess an ideal value for children because the level of perfusion pressure where the brain blood flow begins to decrease is age dependent. The minimum cerebral perfusion pressure for infants and adolescents are thought to be 40-50 mm Hg and 50-60 mm Hg, respectively. The clinical results for those adults with severe head trauma having intracranial pressure (ICP) values of more than 20 mm Hg are found to be worse than the patients with normal values. The prospective study of adult head trauma patients with monitorization and CSF drainage revealed a better result than the group without monitorization. A group of recent publications advise an energetic manipulation for even minimal elevations in ICP (all the values exceeding 15 mm Hg) in order to achieve the best clinical results. Unfortunately the literature data for the pediatric population is limited [7,8].

Sedation analgesia and neuromuscular blockage is another important component of the therapy. Narcotic agents (1-4 mg/kg phentanyl infusion or intermittent bolus therapy in every 1-2 hours), benzodiazepines (0.1-0.3 mg/kg diazepam or midazolam), barbiturates (1-2 mg/kg thiopental or pentobarbital) are important pharmaceuticals in the treatment. Intermittent administration of thiopental and/or lidocaine may be used to decrease the adverse effects of ICP increase experienced during the routine care of the patient such as tracheal aspiration [1,7].

CSF drainage is a good way of decreasing the increased ICP. This procedure has a positive effect on cerebral blood flow in adults. Similar results are obtained in severe head trauma patients related to cerebral blood flow and ICP both by CSF drainage from ventriculostomy and intravenous mannitol infusion. CSF drainage resulted a more prominent increase in jugular venous saturation compared to intravenous mannitol therapy. CSF may be drained either continuously or intermittently regarding the clinical symptoms. Intermittent CSF

drainage is proposed if the ICP is higher than 15 mm Hg and continuous drainage is advised if the value is more than 5 mm Hg. Biochemical investigations on the drained CSF have significant contribution on evaluation of secondary brain injury mechanisms in severe head trauma. The values for lactates, cytokines, and other inflammatory markers besides growth factors and excitator amino acids are important [2,7].

ICP and carotis pressure are both significantly decreased by elevating the head 30 degrees compared to the horizontal position. No negative changes occur in cerebral perfusion pressure or cerebral blood flow by this means. Deducting from these data it can be hypothesized that elevation of head by 30 degrees decreases the ICP with no unfavourable effect on brain perfusion pressure. Elevation of the head and stabilizing in midline position increase the jugular venous return and probably the CSF drainage. ICP is decreased by this means but the effect is limited [7].

Mannitol is widely used for osmotic therapy. It creates a temporary decrease in cerebral blood volume by creating a decrease in blood viscosity without effecting the cerebral blood flow. This is performed by balancing the decrease in viscosity via decreasing the vascular diameter so that a constant cerebral blood flow is maintained according to Pouisueille law. Consequently this situation results a temporary reduction in ICP values. Decrease of ICP for longer durations is generally related to the secondary dehydration process on brain parenchyma due to the osmotic effect of mannitol via intravenous route. This osmotic effect is thought to be efficient in the existence of an intact blood brain barrier [7,8].

One of the most important targets of osmotic therapy is to maintain a normovolemic medium. A treatment strategy consisting of 0.25-0.50g/kg mannitol is usually sufficient for this purpose. It is a known fact that osmotic therapy by mannitol performed on osmolalities higher than 320 mOsm/l has a higher tendency to create renal insufficiency in patients with severe head trauma. There is also a significant amount of data in literature stating that treatment in osmolality values higher than 320 mOsm/l with hypertonic saline solutions is secure and effective [7].

Vasoconstrictor effect on cerebral arteriolar system of hyperventilation in severe head trauma patients is a well-known entity. On the other hand, long and uncontrolled institution of hyperventilation has harmful prognostic results. The effects of hyperventilation on CSF pH

and arteriolar diameter are temporary. Chronic hyperventilation results a decrease in CSF bicarbonate levels which causes a higher affinity to PaCO₂ in vascular structures. This may be a risk for cerebral circulation. Mild or moderate prophylactic hyperventilation instituted in adult severe head trauma patients disclosed a negative effect on prognosis. Besides the unfavourable results of prophylactic hyperventilation, it should be kept in mind that hypercarbia has also a dismal effect on prognosis. Prophylactic hyperventilation in the first twenty-four hours of severe head injury which results a PaCO₂ less than 35 mm Hg should be avoided. In the pediatric age group, PaCO₂ levels may be depressed to values below 30-35 mm Hg. With the aid of profound hypocarbia, late phase ICP increases may be prevented. The major guides for an effective hyperventilation treatment are the cerebral blood flow measurements and / or jugular venous saturation evaluations [7,9].

Barbiturates result ICP decrease by depressing the brain metabolism. The response of brain metabolism due to treatment should be evaluated by EEG monitorization. Monitorization of jugular venous saturation may also be significant. The saturation point for barbiturate coma is establishment of “burst suppression” in EEG. Vigorous treatment against hypotension should be established during barbiturate therapy and the patients should closely be evaluated from the points of insufficient systemic perfusion and decrease in cardiac volume. The most common agents used are pentobarbital or thiopental. Intermittent application of 2-3 mg/kg is sufficient [7,10].

Mild or moderate hypothermia with short intervals in experimental ischemia or trauma models disclose favourable effects in neurological outcome. On the other hand, a temperature increase of 1-2 degrees C even for an hour has negative effect on neuronal healing and blood brain barrier integrity. Clinical experience reveals that epilepsy incidence is lower in those patients receiving hypothermia and ICP levels are depressed in hypothermic era. The recent concept is in favour of hypothermia in selected patients with persistently high ICP values. Physicians should also be aware of posttraumatic central fever and iatrogenic hyperthermia [1,2,7].

Decompressive craniectomy is first described by Cushing more than a century ago. The practice of decompression is generally depends on the experience and technical conditions of the team. There is also some data in literature regarding that it provokes brain edema. The classical knowledge is that in selected trauma cases where increased ICP persists,

decompressive craniectomy yields a decrease in ICP with better consequences. These favourable outcomes are generally from the population of children and young adults. Decompressive procedure performed in the first forty-eight hours present better results [7,10].

Controlled arterial hypertension is a controversial method in the treatment of increased ICP. The threshold for brain perfusion pressure should be 70 mm in severe traumatic brain injury depending on the cerebral blood flow and jugular venous saturation values. Brain perfusion pressure may be increased to 100-140 mm Hg by phenylephrin perfusion regarding the interrelation among vascular diameter, brain blood volume, and intracranial pressure. By this means, intracranial pressure may be decreased via controlled arterial hypertension. This therapeutic procedure may be effective only if the pressure autoregulation depending on cerebral blood flow is sound. There is also the probability of increasing brain edema by high hydrostatic pressure. In practical use, controlled arterial hypertension may only be a supplementary method with careful monitorization [7].

Many complications due to pediatric severe head injury may be encountered during therapy. The convulsions experienced should be treated with confidence. Prophylactic therapy has a role in preventing the early posttraumatic epilepsy. The therapeutic dose should be reached in the first twenty-four hours for prevention. Serum sodium concentration is extremely important and should closely be followed-up. Hyponatremia may be related to inappropriate ADH syndrome (SIADH) or cerebral salt wasting process. Therapy directed to the right diagnosis is extremely important. Liquid restriction is essential for the treatment of SIADH. Therapy for cerebral salt wasting syndrome depends on the replacement of isotonic or hypotonic solutions [10].

It is essential to organize the nutritional support - i.e. protein and energy metabolism- in a severely head injured patient who has an active catabolic state. A deficit of 10000KCAL in a severely injured adult patient has a significant correlation with increased mortality risk. This gap may easily evolve within a week in intensive care unit conditions if it is overlooked. A reduction rate of 50% has been reported in septic complications and the duration in intensive care units in patients having jejunal tubes within the first 36 hours compared to the late ones where the procedure is postponed for anticipated resolution of gastric atonia [7].

Complications due to overnutrition should not also be overlooked. There is the risk of hyperglycemia in parenteral and hypoosmolality in enteral nutrition. Extreme care should be paid to blood glucose and electrolyte levels and caloric evaluations. Glucocorticoids should not be prescribed for patients with severe traumatic brain injury [7-10].

As a result the management of a child with severe traumatic brain injury requires multidisciplinary approach. Rapid and vigorous resuscitation with establishment of a secure airway and stabilization of vital parameters is essential. Preceding the first evaluation and the necessary surgical interventions optimizing the brain perfusion, establishing the metabolic balance, and preventing brain edema are the main goals of therapy [10].

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