INTRODUCTION

Anesthesia Management in Trauma

Trauma, which means wound in ancient Greek, is the leading cause of death in the 1-44 age group, and the third cause of death following cancer and cardiovascular disease in all age groups. Trauma is defined as tissue damage characterized by structural changes and physiological disorders due to mechanical, thermal, electrical and chemical energies, ionized or nuclear radiation or absence of essential elements of life such as oxygen and heat. Trauma has many reasons such as traffic accidents, work accidents and falling from height (1,2). These patients need a systematic anesthesia management in posttraumatic evaluation, airway management, resuscitation, possible surgical process, intensive care follow-up and treatment. The nature of trauma, uncontrollable bleeding after trauma, coagulation anomalies, hypothermia, shock, acidosis disrupt the normal homeostatic mechanism and are associated with poor clinical course. Another paradox is the nature of unexplained events, insufficient anamnesis information and the necessity of emergency intervention in trauma cases. This section aims to discuss anesthesia management with current guidelines.

Keywords: Neurotrauma, thoracic trauma, anesthesia, guidelines
ABC stages of cardiopulmonary resuscitation (CPR). Airway must be secured first for effective intervention. All trauma patients should be considered to have cervical damage until they are ruled out, and cervical stabilization should be provided during interventions (Figures 1, 2). In the trauma patient, inadequate anamnesis, full stomach, the possibility of cervical trauma and maxillofacial injury should be considered and the physician should be prepared for difficult airway management. Algorithms have been developed for difficult airway management (Figure 3). Considering the location of the patient’s injury and experience of the anesthesiologist, the appropriate method such as oropharyngeal airway, supraglottic airway devices, orotracheal intubation, nasal intubation, tracheotomy or cricothyroidotomy is performed in order to provide airway patency (9). Auscultation and confirmation by capnography should be performed in the patient with secured airway. Circulation should be checked; fluid resuscitation should be started and bleeding, if any, should be controlled. Hypothermia in trauma patients is known to be a cause that increases mortality and morbidity (10). Passive isolation or active heating techniques should be used in these patients, and fluids, blood and blood products to be used in infusion should be heated and unwanted hypothermia should be prevented. Since trauma patients may have life-threatening injuries such as pneumothorax and pericardial tamponade, surgical evaluation should be performed concurrently with CPR. Possible injuries should be determined by laboratory tests, invasive-noninvasive radiological imaging methods and treatment plan should be designed (6,9). In trauma patients, systemic inflammatory response to trauma can be reduced by early and appropriately planned fluid resuscitation (11). Early detection and effective resuscitation of post-traumatic shock-prone patients are life saving. Hypovolemic shock is the inadequate tissue perfusion resulting from decreased intravascular volume. In order to diagnose shock that emerges clinically with findings such as tachypnea, tachycardia, hypotension and low pulse pressure,

<table>
<thead>
<tr>
<th>GCS</th>
<th>SBP</th>
<th>RR</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-15</td>
<td>&gt;89</td>
<td>10-29</td>
<td>4</td>
</tr>
<tr>
<td>9-12</td>
<td>76-89</td>
<td>&gt;29</td>
<td>3</td>
</tr>
<tr>
<td>6-8</td>
<td>50-75</td>
<td>6-9</td>
<td>2</td>
</tr>
<tr>
<td>4-5</td>
<td>1-49</td>
<td>1-5</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

GCS: Glaskow Coma score, SBP: Systolic blood pressure, RR: Rate ratio

**Table 1. Revised Trauma score**

**Table 2. Clinical signs of shock according to blood loss**

<table>
<thead>
<tr>
<th>Blood loss</th>
<th>Pulse</th>
<th>SBP</th>
<th>Pulse pressure</th>
<th>Capillary fountain</th>
<th>Respiratory</th>
<th>CNS</th>
<th>Urine output</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;15%, 1000 mL</td>
<td>n</td>
<td>↓</td>
<td>n</td>
<td>Delayed</td>
<td>Light tachypnea</td>
<td>Anxiety</td>
<td>20-30 mL/s</td>
</tr>
<tr>
<td>30%-40%, 1500-2000 mL</td>
<td>&gt;120 weak</td>
<td>↓</td>
<td>↓</td>
<td>Delayed</td>
<td>Serious tachypnea</td>
<td>Confused</td>
<td>20 mL/s</td>
</tr>
<tr>
<td>&gt;40%, &gt;2000 mL</td>
<td>&gt;140 nonpalpabl</td>
<td>↓↓</td>
<td>↓↓</td>
<td>Ø</td>
<td>Serious tachypnea</td>
<td>Lethargic</td>
<td>Ø</td>
</tr>
</tbody>
</table>

CNS: Central nervous system, SBP: Systolic blood pressure
lactate measurements, determination of base-excess, and the shock index determined by the ratio of heart rate to systolic blood pressure being above 0.9 may be helpful (Table 2) (12-15). Early fluid replacement is important in correcting hypotension in hypovolemic shock. Crystalloid, colloid fluids, whole blood and blood products are used according to need. More than 10 units of erythrocyte suspension red blood cell (RBC) within 24 hours is called massive blood transfusion (16,17). The answer to question how much transfusion should be performed is still unclear, but massive transfusion protocol with 1:1.5 fresh frozen plasma (FFP)/RBC within 24 hours is recommended if the platelet count is <100,000/mm² (21). It has been shown that the use of antifibrinolytic tranexamic acid reduces mortality in patients with bleeding (22). The usefulness of the use of recombinant activated Factor VIIa is controversial, although there are studies showing that early use reduces mortality (23,24). The use of norepinephrine and vasopressin has been found to be beneficial in animal models of trauma, but there are no large-scale studies (11,25). The use of fibrinogen concentrate has been shown to reduce perioperative bleeding by 32% and reduce the need for transfusion (26,27). In the follow-up of these patients, the mean arterial pressure should not be reduced below the brain perfusion pressure and should be higher than 50-60 mmHg. Follow-up of central venous pressure and hourly urine output is beneficial in terms of anticoagulant factors and antifibrinolytic proteins, which decrease with dilution as a result of massive blood transfusion, lead to coagulopathy. It is important to replace with FFP and platelet suspensions in the early period for treatment. Platelet suspension is recommended if the platelet count is <100,000/mm² (21). It has been shown that the use of antifibrinolytic tranexamic acid reduces mortality in patients with bleeding (22). The usefulness of the use of recombinant activated Factor VIIa is controversial, although there are studies showing that early use reduces mortality (23,24). The use of norepinephrine and vasopressin has been found to be beneficial in animal models of trauma, but there are no large-scale studies (11,25). The use of fibrinogen concentrate has been shown to reduce perioperative bleeding by 32% and reduce the need for transfusion (26,27). In the follow-up of these patients, the mean arterial pressure should not be reduced below the brain perfusion pressure and should be higher than 50-60 mmHg. Follow-up of central venous pressure and hourly urine output is beneficial in terms of
showing vital organ perfusion (9). Damage control resuscitation is a relatively new concept in the management of trauma patients consisting of permissive hypotension, prevention of acidemia, reheating and correction of ionized calcium. In patients without contraindications, targeting of mean arterial pressure of “65 mmHg or systolic arterial pressure of” 90 mmHg is called “permissive hypotension” (28). Large amounts of ringer lactate solution to be used in fluid resuscitation may cause cerebral edema. Excessive use of dextrose solutions may cause ischemic brain damage and use of large amounts of isotonic solution may cause hyperchloremic metabolic acidosis. Colloid solutions are effective in providing intravascular volume, but increase the tendency of pulmonary edema with increased hydrostatic pressure. If there is microvascular permeability disorder in the lungs, oncotic pressure increases in the interstitium due to colloid escape from the endothelium, and more fluid may accumulate in the pulmonary interstitium and alveoli, and prolong the need for mechanical ventilation (13). In trauma, insufficient organ perfusion results in metabolic acidosis. Hypothermia, acidosis and coagulopathy are known as the fatal triad of trauma (29). Acid-base imbalance can be eliminated by hydration and correcting organ perfusion. Uncorrected lactic acidosis is defined as an independent risk factor for multiorgan failure (30). Multiorgan failure may occur 12 hours after shock after trauma and may be delayed up to 7-10 days, which is one of the most important causes of mortality (13,31).

ANESTHESIA IN TRAUMA

Sedation Anesthesia

In order to perform simple fracture reduction, shoulder dislocation, tube thoracostomy, and cardioversion, patients may need anesthesia applications that protect cardiorespiratory functions and protective reflexes (32). As in all anesthesia applications, patient needs to be evaluated for sedoanalgesia, monitored and the necessary emergency response equipment should be available. Regarding anesthetic agent, single or combined applications of conventional benzodiazepine (midazolam), propofol, ketamine, ketofol and fentanyl have been studied. In these studies, ketofol has been found to be superior due to rapid onset, effective sedation depth, low values in sensation of pain, and high patient and staff satisfaction (33-35).

General Anesthesia

General anesthesia begins with rapid induction and rapid intubation strategy, but there is no optimal anesthetic agent for patients with hemorrhagic shock. The most commonly used agents for induction are thiopental sodium, propofol, etomidate and ketamine. Thiopental sodium is a barbiturate commonly used in induction since 1934. Since intracranial pressure (ICP) increases due to cerebral hemorrhage and edema in head trauma, barbiturates, which lead to a decrease in cerebral blood flow (CBF) and ICP by cerebral vasoconstriction, may be preferred (6,36). However, it has been reported that induction with thiopental sodium increases critical respiratory problems approximately 2-fold in the postoperative period. The dose of intravenous (IV) induction is 3-6 mg/kg (6,37). As it causes venous dilatation and hypotension, it is recommended to reduce the dose in patients with unstable hemodynamics (38). Having high lipophilic properties cause propofol to pass through the blood-brain barrier and reach the central nervous system, causing the effect to start very quickly and to be short-term. The dose of IV induction is 1-2.5 mg/kg. It reduces CBF and ICP, and may be preferred in patients with head trauma, but it has myocardial depressant effect. Caution should be exercised in the use of propofol, which causes peripheral vasodilation and reduces systemic vascular resistance, in hemodynamically unstable trauma patients (6,39). Etomidate is an induction agent that acts rapidly with gamma-aminobutyric acid receptor stimulation. The dose of IV induction is 0.3 mg/kg (6). It is widely used in trauma patients because it has a rapid onset and does not impair hemodynamics (40). In traumatic brain injury, etomidate may be preferred because it provides cerebral protection by decreasing cerebral metabolic rate of oxygen (CMRO2), CBF and ICP (41). It has been shown that etomidate can lead to adrenal suppression even with a single dose in rapid intubation (42). Etomidate use in trauma patients was also associated with nosocomial pneumonia (43). Ketamine increases arterial blood pressure, heart rate and cardiac output through central stimulation of the sympathetic nervous system and inhibition of norepinephrine reuptake. It shows its effect on N-methyl-D-aspartate receptors and is a dissociative agent (41). It is suitable for use in cardiac tamponade and hypovolemic patients in trauma, but may lead to cardiac hypotension and cardiovascular collapse in hemorrhagic shock patients with previous maximum sympathetic stimulation and previously depleted catecholamines, it should be administered in small doses by titrating in trauma patients (6,44). It is a potent bronchodilator and a good option for induction, especially in asthma patients with reactive airway. It increases CMRO2, CBF and ICP in accordance with cardiac effects (6,41,45). This limits the use of ketamine in traumatic brain injuries. However, some studies have reported that it increases cerebral perfusion and has no significant effect on ICP (46). Compared with opioids, the use of ketamine in trauma patients has been associated with an
is a preferred opioid in trauma patients because of its minimal effects on hemodynamics. Fentanyl suppresses increased catecholamines, antidiuretic hormone and cortisol secretion in stress response. It prevents bronchoconstriction against airway stimulation during intubation. However, it may cause chest wall rigidity (6,56). In many studies, it was emphasized that opioid use should be titrated according to the response (50). Midazolam, a fast acting benzodiazepine, provides sedation and amnesia. Induction dose is 0.2 mg/kg IV. It has no analgesic effect and its use is limited in trauma patients because it decreases mean arterial blood pressure. It is frequently used in low dose (0.05 mg/kg) in the emergency department (37,57).

**Regional Anesthesia**

In trauma, regional anesthesia is contraindicated if the patient is not hemodynamically stable. However, regional technique may be used to increase peripheral blood flow by vasodilatation by blocking sympathetic innervation especially in amputations and extremity trauma with stable hemodynamics (6). Brachial plexus blocks are more common in upper extremity injuries and central blocks are more common in lower extremity injuries. Cases where central and peripheral blocks are applied together have also been reported (58,59). Trauma is a chaotic process involving many pathophysiological changes. In order for anesthetists to cope with high mortality and morbidity in trauma, trauma management procedures should be a good implementer of algorithms. Rapid resuscitation in the traumatic patient, effective surgical hemostasis, and effective struggle with hypothermia, acidosis and coagulopathy will be the secret of success.

**Ethics**

**Peer-review:** Internally peer-reviewed.

**Authorship Contributions**


**Conflict of Interest:** No conflict of interest was declared by the authors.

**Financial Disclosure:** The authors declared that this study received no financial support.

**REFERENCES**


