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Seconds Save Lives: Prehospital Strategies for Managing Traumatic Brain Injuries

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INTRODUCTION

Henry VIII of England is one of the most infamous rulers of the 15 century, known primarily for murdering many of his wives [1]. Despite initially being a beloved and intellectual individual earlier in life, after a jousting match in which he hit his head violently upon falling off a horse, he became violent and erratic [1]. Many researchers today attribute his drastic change in nature and behavior to his traumatic brain injury [1].

Traumatic brain injury (TBI) affects a multitude of people around the world, and many studies have placed the number in the millions [2]. The groups most affected by TBI include the younger populations ranging from very young, between 0 to 4, and between 15 to 24 years old [2]. Although, according to the National Library of Medicine, there is a discrepancy between the actual number of cases and the number of reported cases, as many cases go unreported [2]. Many levels of traumatic brain injury can have minimal effects to serious consequences on the individual [2].

Primary Assessment and Stabilization

Traumatic brain injury is one of the most significant causes of mortalities and morbidities in the younger population around the globe [3]. For patients with major traumatic brain injury cases in which emergency management is necessary, quick assessment and stabilization and other methods of prehospital care may be needed for survival [4]. TBI classification is an

important way to distinguish types of brain injuries [3]. Prehospital management of traumatic brain injury requires classification into a primary versus a secondary brain injury, which refers to the type of injury [3]. Specifically, primary brain injuries can be categorized as those that result from kinetic energy being transferred to the brain tissue. In contrast, secondary brain injury can be classified as a brain injury resulting from an external factor, including hypoxemia, hypo-, as well as hyperthermia, hypoglycemia or hyperglycemia, and seizures, among others [3].

The Korean Journal of Anesthesiology discusses the protocol needed for pre-hospital primary assessments for the diagnosis of traumatic brain injury of a patient [3]. Management involves stabilizing airways and oxygenation provision and addressing any hypoxia or high oxygen levels in the body by positioning airways if needed or using a bag-valve mask [3]. Next, ventilation and blood pressure must be managed. For assessments involving the patient's neurological state, the Glasgow Coma scale can be used to determine the patient's level of consciousness [3]. Applications of the Glasgow Coma scale can be in any neurological examination scenario, mainly when trauma has been dealt to the brain, especially when there is a loss of consciousness for the patient. By stabilizing blood pressure and cerebral perfusion pressure, emergency management technicians can ensure the best outcomes for TBI patients [3]. By managing fluid levels for TBI patients with hypotension, especially those at risk of hypovolemia from extracranial hemorrhage, prehospital care can ensure better outcomes for TBI patients in the future [3].

Airway Management in TBI Patients

In addition to physical damage from the blunt or penetrating force, a major contributor to brain damage and, ultimately, death in TBIs is hypoxia or a lack of oxygen to the brain. Because the brain is incredibly metabolically active, hypoxia and hypoperfusion can cause irreversible tissue damage within minutes [5]. This occurs because a key indicator of TBIs and rising intracranial pressure (ICP) is Cushing's Triad, a widening pulse point, bradycardia, and irregular breathing [6]. As a result, it becomes challenging to intake and distribute oxygen, as the patient does not have a patent airway and cannot regulate respiration. In this situation, pre-hospital airway intervention is crucial in ensuring patient survival. EMTs and Paramedics have a variety of ventilation techniques at their disposal, such as nasal cannulas,

non-rebreather masks (NRB), bag valve masks (BVM), and C-pap. These different techniques are utilized given different circumstances and severity of airway compromise. Across the board, studies have shown that any pre-hospital airway intervention is better than no intervention [4]. However, recent studies show that positive pressure ventilation (PPV), provided by C-pap or tracheotomy, can be a superior form of ventilation in patients with TBIs. A study combined data regarding airway intervention from a pool of 21,852 TBI patients: of these patients, 5,022 were given pre-hospital PPV instead of a cannula or NRB. The study showed a statistically significant increase in survival to hospital admission amongst all 5,022 patients versus the rest of the group. Furthermore, amongst severe TBI patients, prehospital PPV also increased the chance of survival after hospital discharge [4]. Unlike a cannula or NRB, PPV forces continuous oxygen into a patient, ensuring control over the airway and preventing a hypoxic environment. This is useful because even if the patient is having difficulty breathing on their own, hypoxia can be prevented with PPV specifically.

Spinal Precautions and Immobilization

TBIs have compounding complications that affect other parts of the nervous system, such as the spinal cord. As a result, the spinal and head must be stabilized to prevent further injury. Geriatric patients falling greater than three feet and motor vehicle accidents are all examples of when spinal motion restriction (SMR) is necessary and can help preserve central nervous system health. However, unlike maintaining a patent airway, there are many more contraindications to providing SMR, and studies show several cases where the use of SMR is detrimental to the patient. While, in theory, completely restricting motion would be enough to stabilize the body, this has other complications. For instance, using rigid cervical collars does not mimic the natural curvature of time, forcing the patient into a contorted and uncomfortable position [7].

Furthermore, rigid cervical collars cannot be used in case of penetrating trauma. Patients experiencing cerebral or spinal penetrating trauma and given spinal motion restriction have twice as high mortality rates as those who did not [8]. Additionally, studies show that the use of spinal motion restriction, either with cervical collars or backboards, when contraindicated, has the additional complication of further restricting respiration, which, as previously discussed, is one of the most critical aspects to preserve in TBIs [8]. From this

data, EMS guidelines can be modified to prioritize airway management over SMR, or at the very least, use careful discretion in whether SMR is required.

Administering Fluids and Medications

One sometimes overlooked part of prehospital care for TBI patients is fluid resuscitation. Essentially, this means maintaining the cerebral perfusion pressure. Normal saline is often used to perform fluid resuscitation. One drawback to the use of normal saline for this is possible overhydration of the patient, which can manifest as exacerbated cerebral edema. Hypertonic saline is a potential alternative currently being studied [9]. Clinically, hypertonic saline has previously been used to treat hyponatremia, as a mucus thinner in patients with cystic fibrosis, and to treat increased intracranial pressure. Another part of TBI prehospital management is the administration of many medications, typically through an IV that has already been established as a patient has been put in the back of the ambulance. On their way to the hospital, two main types of drugs are administered to patients for a higher level of care: analgesics and anticonvulsants. For analgesics, a paramedic may choose either opioids like fentanyl or morphine, or they might choose a non-opioid option like ketorolac [10]. Another drug being explored for prehospital administration in patients with intracranial hemorrhage is Tranexamic Acid. It prevents clot breakdown and decreases bleeding overall. The research examines the potential benefits of TXA in reducing intracranial hemorrhage and improving outcomes when administered by paramedics before hospital arrival. It provides insights into dosage, timing, and protocols for prehospital TXA use in TBI cases [11]. Overhydration can lead to increased intracranial pressure, worsening patient outcomes. Therefore, fluid administration should be carefully monitored, and hypotonic solutions should be avoided. Maintaining systolic blood pressure between 100-110 mmHg is recommended to ensure adequate cerebral perfusion without causing additional harm [12].

Prehospital and Clinical Monitoring and Documentation

Several neuromonitoring techniques and types of documentation are necessary for ensuring proper management of a patient with traumatic brain injury. Documenting blood pressure, ventilation, and oxygen levels is important to ensure the best outcomes for TBI patients [3]. Neuromonitoring techniques and managing intracranial pressure levels, oxygenation, and

many other techniques conducted in a prehospital capacity can ensure better scenarios for traumatic brain injury patients in the hospital settings [3]. Intracranial pressure documentation and monitoring techniques for patients with TBI have directly beneficial correlations in future outcomes. However, many techniques are not used in a universal capacity [13]. ICP monitoring may be conducted in a prehospital setting through ultrasound tests, although these resources may be limited in remote or rural areas [14]. While there are limited monitoring techniques in a prehospital setting, many monitoring techniques are performed in a clinical capacity that can ensure better outcomes for TBI patients. Neuromonitoring techniques for cerebral perfusion pressure for a patient with a traumatic brain injury entail monitoring and documentation of the jugular venous oxygen saturation to determine the global cerebral oxygen delivery uptake and delivery and ensure a balance between them [3]. Insertion of catheters into the dominant internal jugular vein is an example of an invasive monitoring technique that ensures proper levels of jugular venous oxygen saturation, resulting in better outcomes for TBI. However, this type of monitoring is often conducted in a hospital. This is not routinely performed in prehospital settings, although this has become a debate amongst proponents of more monitoring technology in a prehospital or emergency setting [13]. Thus, various monitoring techniques for documentation exist to ensure better survivability for TBI patients. While there are limitations with prehospital settings and monitoring and documentation for TBI patients, improvements in technology are providing better care and survival rates for patients with traumatic brain injuries [13].

Transport Considerations for TBI Patients

Effective management of traumatic brain injury (TBI) requires meticulous transport considerations, as early interventions significantly influence patient outcomes and help minimize secondary injuries. The process begins with assessing injury severity using the Glasgow Coma Scale (GCS); a score below 13 typically necessitates rapid transport to a trauma center equipped with neurosurgical capabilities [15]. Immediate stabilization is paramount, focusing on airway management to prevent hypoxia and ensuring adequate oxygenation through supplemental oxygen or intubation for severe cases. Monitoring intracranial pressure (ICP) and cerebral perfusion pressure (CPP) during transport helps mitigate cerebral herniation and ischemia risks.

Decisions on transport mode, such as using the ground or air, depend on the patient's condition, distance to a trauma center, and environmental factors such as weather [16]. Air transport, often by helicopter, benefits critically injured patients due to its speed and advanced care capabilities during transit. However, precautions must be taken to prevent altitude-related complications like pneumocephalus in cases of cranial fractures [17]. Additionally, minimizing patient movement using spinal precautions, such as cervical collars and backboards, is essential to avoid exacerbating injuries. Maintaining normothermia by keeping the patient warm and ensuring adequate ventilation prevents hypoxia, hypercarbia, and worsening brain injury [18]. Patients with severe TBI, typically with GCS scores between three and eight, should be transported directly to Level I trauma centers with round-the-clock neurosurgical expertise while trained emergency response teams ensure timely triage and field stabilization for optimal outcomes [17].

Advances in Prehospital Care for TBIs- Deepti

The Brain Trauma Foundation's third edition of evidence-based guidelines for the prehospital management of TBI, published in April 2023, offers updated protocols to assist emergency medical services (EMS) in delivering optimal care. These guidelines emphasize the importance of maintaining adequate oxygenation and blood pressure and timely identification and management of intracranial pressure [19]. Technological innovations, such as portable imaging devices and point-of-care diagnostics, have been developed to aid in rapidly assessing TBI severity in the field.

Recent research has explored various pre-hospital treatments to improve outcomes for TBI patients. The Excellence in Prehospital Injury Care (EPIC) study, conducted in Arizona, implemented statewide prehospital TBI treatment guidelines and demonstrated a significant association with improved survival rates among patients with severe TBI. The study emphasized the importance of evidence-based protocols in prehospital settings [20]. Additionally, updates are constantly being made to these protocols with some of the most recent changing spinal immobilization, where rigid cervical collars have been shown to have complications, and a more selective approach is taken as to what parts of the patients are immobilized. Additionally, more emphasis is being placed on ventilation and temperature management than previously.

Mental and Emotional Support for TBI Patients and Families

Mental and emotional support for patients with TBI and their families is a highly acute need because the psychosocial challenges that must be overcome on account of the injury are immense. For instance, several studies have pointed out that there is a significant shrinkage in social support networks, which results in feelings of loneliness and might lead to depression and anxiety among the survivors of TBI. For families, personality changes and emotional sequelae, such as mood swings and irritability, in their loved ones often result in increased stress and emotional burdens. Long-term rehabilitation efforts must prioritize building strong social support systems for the patient and their family. This includes fostering opportunities for re-establishing friendships, engaging in leisure activities, and participating in community networks to mitigate social isolation and improve quality of life [21].

Counseling services and support groups are recommended to help families navigate the emotional impact of the injury and adapt to their new roles in caregiving. Professionals, including psychologists and social workers, should intervene early to address cascading psychosocial deficits, such as anxiety and depression, which can exacerbate over time without proper management. Educational resources for caregivers and tailored therapy sessions that include the patient and family members can bridge the gap in understanding the patient's needs. Proactive approaches in community-based rehabilitation focusing on patients' and their families' emotional and psychological health are crucial for a sustainable recovery and reintegration into society [21].

Conclusion

Traumatic brain injuries (TBIs) require rapid assessment and stabilization to prevent further damage. Emergency responders prioritize airway, breathing, and circulation (ABCs) while using tools like the Glasgow Coma Scale (GCS) to evaluate severity and monitor for increased intracranial pressure. Effective airway management and oxygenation are critical, alongside careful administration of fluids and medications, to avoid complications like overhydration or unstable blood pressure. Technology advancements, such as telemedicine and portable

diagnostics, enhance pre-hospital care. Clear documentation ensures smooth transitions to hospital treatment while addressing emotional and informational needs and supports patients and families through recovery.

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