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Case report

# Severe Traumatic Brain Injury after the Assault with an Axe Handle

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**A B S T R A C T**

*Traumatic brain injuries represent a major cause of death and disability. We present a case of a 47-year-old patient who sustained a severe brain injury after being assaulted with a handle of an axe. The patient underwent numerous surgeries by various specialists during several months. Following a few failed attempts to cover the skull defects, the vacuum-assisted closure system had been utilized with great success in healing of her complex head wound. Traumatic brain injury requires great effort and collaboration in order to rehabilitate people to the most independent level of functioning possible.*

***Key words:*** *brain injuries, violence, skin transplantation, surgical flaps, Negative-Pressure Wound Therapy*

## Introduction

Traumatic brain injury (TBI) is a major cause of death and disability worldwide. Most affected groups are male adolescents and young adults ages 15 to 24, and elderly people of both sexes 75 years and older. Each year in the United States alone nearly 1.6 million people experience a TBI[1,2], and roughly 60 000 people die from it[1,3,4]. Additionally, there are an estimated 70 000 to 90 000 patients left with a permanent neurological disabilities following a TBI[3–6].

Motor vehicle accidents represent the most common cause of head injuries in teenagers and young adults[7–9]. The next largest group of head injuries occurs after falls and is more common at the extremes of age. Finally there are nonfatal violence-related head injuries, such as assaults and child abuse[10–12]. It has been reported that half of all TBIs involve alcohol use[13,14].

Traumatic brain injury consists of primary and secondary processes. Primary brain injury is the irreversible morphological damage caused at the time of the impact[15]. However after this initial trauma, brain injury continues to evolve. This evolving damage is referred to as a secondary injury, which usually prolongs hospitalization, as well as exacerbates and increases disability of the injured patients[16]. It is due to a more thorough understanding of the physiological events leading to secondary neuronal injury, as well as advances in the care of critically ill patients that the management of TBI has progressed dramatically in the last two decades.

We present a case of a 47-year-old female patient suffering from a severe traumatic brain injury after an assault with an axe handle. Following a complex and extended medical treatment, which included a successful application of the vacuum-assisted closure system to treat extensive head wounds, the patient recovered remarkably.

## Case Report

In a small grocery store, within a scope of a psychiatric institution localized on an island, one of the psychiatric patients heavily assaulted a 47-year-old female shop assistant during her rest break. He approached her from behind, while she was locking the door, repetitively punching her head and face with a plastic handle of an axe, 35

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*Fig. 1. As a result of a brutal attack the patient sustained multiple facial (A) and cranial injuries (B).*

cm in length. The shop assistant lost consciousness and fell to the floor. Following the assault, the attacker hid her inside the store where she was found approximately one hour later lying in a pool of blood with major craniofacial injuries.

Upon arrival of the Emergency Medical Team the patient was unconscious and presented with difficulty in breathing, multiple cranial injuries, raccoon eyes and severe facial swelling (Figure 1). Neurological findings included a comatose mental state (GCS=3). In the field, due to prevention of the secondary injury to the spinal cord, proper immobilization of the patient was conducted. She was placed on the hard spine board from her head to feet, with rigid collar around her neck and a padded head motion-restriction device. After securing the patients cervical and thoracolumbar spine, she was rapidly intubated with manual in-line axial traction and put on 100% oxygen. The patient was hemodynamically unstable, confirmed by vital signs including a blood pressure of 85/50 mmHg, pulse rate of 137 beats per minute, respiratory rate of 28 breaths per minute, and $SpO_2$ 82%. After the peripheral intravenous access was established, the restoration of blood pressure and normal circulating volume was started with crystalloid solution.

Expeditious transport of the patient via ambulance car to the remote regional trauma center with neurological and neurosurgical services was originated. To optimize the patient's transportation, which lasted 4 hours, the patient was analgosedated. Following a telephone consultation with a neurosurgeon from the regional trauma center, mannitol was added to the therapy during transportation because the patient presented with dilatation of the left eye pupil and no constriction in response to light, both signs of transtentorial herniation.

Upon arrival to the Emergency Department of the regional trauma center a computed tomography (CT) scan was immediately performed. It revealed pint size focal contusions extending both infratentorially and supratentorially in the left subcortical occipitotemporal area, along with fractured bone structures and spilled bloody content in associated cortical sulci and parenchyma. In the same area of the parenchyma, teared off free skeletal fragments were visible. Epidural hematoma in left occipitotemporal area was present, 5 mm in thickness, with an equivalent midline shift. Pneumocephalus was seen both supratentorially and infratentorially. Besides multiple shred fractures of the left side of the occipital bone and squama of the left temporal bone, there were longitudinal and transversal fractures of the pyramid of the left temporal bone with dislocation of the structures mainly to the side of the pyramids. The initial CT scan also demonstrated fractures of the wing of the right sphenoid bone, base of the frontal bone and nasal spina with the fracture extending to the roof of the orbits. Fracture of the left sphenoid sinus walls, right zygomatic bone and all walls of both maxillary sinuses, as well as several fractures of the dorsum and wings of both nasal bones were also visible (Figure 2). Chest radiography demonstrated a normal cardiac silhouette, clear lung fields, and no fracture. Radiography of cervical and thoracolumbar spine was unremarkable, while that of the left hand revealed a fracture of the proximal phalanx of the 2nd finger.

Following a neurosurgical examination, emergency craniotomy for brain decompression and removal of the left epidural occipitotemporal hematoma was carried out under general anesthesia. Temporary ventriculostomy for cerebrospinal fluid pressure monitoring and drainage was put in place. Reposition, reconstruction and ostheosynthesis of the fractured viscerocranium bones and ostheosynthesis of the 2$^{nd}$ left hand finger were performed.

After the surgery the patient was transferred to the Intensive Care Unit (ICU). Her vital signs were stabile, and high dose barbiturate therapy was set in motion. Percutaneous dilatational tracheotomy was performed and the patient was put on mechanical ventilation. The ventilator settings were adjusted to maintain the $PaCO_2$ between 30 mmHg and 49 mmHg and the $PaO_2$ above 70 mmHg. The patient's head was elevated to 30° to reduce the risk of ventilator-associated pneumonia. Swan-Ganz catheter was placed to assist with fluid resuscitation, and the treatment with broad-spectrum intravenous antibiotics and antiedematous agents was initiated. Routine stress ulcer prophylaxis and antithrombolitic low-dose heparin therapy was administered. A follow up CT head scan performed on post-trauma day 2 (PTD 2) showed a substantial regression of brain lesions.

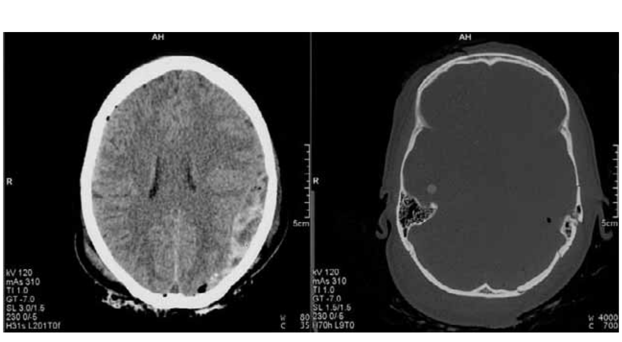

*Fig. 2. The initial head CT scan revealed, among other findings, an epidural hematoma in left occipitotemporal area and multiple shred fractures of the left side of the occipital bone and squama of the left temporal bone.*

*Fig. 3. Skull wound, after debridement (A) and split-thickness skin grafting (B).*

On PTD 5, skull wound debridement followed by split-thickness skin grafting was carried out to cover the bony defects in the left occipitotemporal area (Figure 3). Ten days after this procedure (PTD 15) physical examination revealed that the skin grafts did not survive and that necrosis has developed. The following day (PTD 16) a free latissimus dorsi myocutaneous flap transfer was performed to cover the scalp and skull defects. The scalp defect was 20 cm × 12 cm in size after excision of the skin necrosis. A latissimus dorsi myocutaneous flap measuring 25 cm × 15 cm was harvested from the left side of the back. The superior thyroid artery and external jugular vein were ablated from the left side of the neck for preparation of the recipient vessels. The left superior thyroid artery and left external jugular vein were anastomosed end-to-end to the left subscapular artery and vein. The exposed portion of the latissimus dorsi myocutaneous flap was covered with a split-thickness skin graft. Urokinase was administered at 240 000 units per day for one week to prevent thrombosis.

After the surgery the patient was once again transferred to the ICU where the following day (PTD 17) she was awakened from the induced coma. Her neurological deficits gradually improved, apart from mild right hemiparesis. At that time a course of intensive physical therapy, three times a week, was initiated.

Unfortunately, one month after the flap transfer it was clear that the local flap did not survive, probably due to thrombosis. Physical examination revealed a skin defect of about 10 cm in diameter due to skin necrosis in the left occipitotemporal region. Excision of the necrotic tissue was performed on PTD 48 leaving a scalp defect, 12 cm in diameter. At that point a vacuum-assisted closure system (VAC) (Kinetic Concepts Inc., San Antonio, TX) had been utilized to help in the healing process of this complex wound. The VAC system consisted of the ATS model. Negative pressures ranging from 100 to 125 mm Hg were applied to black polyurethane foam sponge (Kinetic Concepts Inc., San Antonio, TX) trimmed to the appropriate wound size. An occlusive seal over the VAC sponge was maintained by a combination of the occlusive dressing, Tegaderm, Skin Prep, and Benzoine (Kinetic Concepts Inc.) (Figure 4). The VAC dressings were changed two times a week, under general anesthesia, for the next three weeks, until the wound was ready for split thickness meshed graft. On PTD 66, a split thickness skin graft was harvested from the left thigh and meshed at a 1:3 ratio.

*Fig. 4. Vacuum-assisted closure system had been utilized during a period of three weeks to help in the healing process of the head wound.*

Ten days after the last plastic surgery (PTD 76) the patient became febrile and tracheal culture swabs showed Enterobacter aerogenes and methicillin-resistant Staphylococcus aureus (MRSA). Vancomycin and cefepim were added to the therapy. Four days later the patient was removed from mechanical ventilation after passing a spontaneous breathing trial and was breathing through tracheal cannula (PTD 80). During the next four weeks the patient's overall health continued to improve. She was alert, oriented, and cardiopulmonary stable with good hepato-renal functions.

Four months after the traumatic event the patient presented with difficulty in swallowing (PTD 122). Due to extensive cachexia a percutaneous endoscopic gastrostomy (PEG) was performed (PTD 124). Four weeks later the patient experienced productive cough, difficulty in breathing, fever and malaise (PTD 152). Chest X-ray showed patchy areas of increased density in the base of the left lung and left side pleural effusion. Administered therapy with vancomycin was successful and X-ray performed one week later demonstrated no signs of infection (PTD 159). Six weeks after its introduction PEG was removed (PTD 166). Removal of tracheal cannula was performed 76 days after the insertion (PTD 168). The epithelization of all wounds was completed (Figure 5), leaving a mild right hemiparesis.

*Fig. 5. Final result, skin grafting of granulations and epithelization of surrounding tissue.*

The patient was discharged six months after the attack (PTD 182) and scheduled for regular follow up examinations by neurologists, psychologists, as well as neurosurgeons and plastic surgeons. She was back to her daily routine and was doing remarkably well.

## Discussion

TBI is considered to be a dual insult composed of primary and secondary processes. Primary brain injury occurs at the time of the trauma and may be widespread or localized[15]. Localized brain injury is typically associated with blows to the cranium, while widespread or diffuse axonal injury is usually a result of a rapid acceleration/deceleration, or rotation of the brain. After the initial trauma, injury to the brain continues to evolve, meaning that exacerbation of the primary injury can happen at any time after the initial event. This evolving damage of the injured tissue is referred to as secondary brain injury[16].

Major outcome determinant for TBI is the severity of the primary injury[17]. However, since it represents the irreversible anatomical damage of the brain, the focus during resuscitation should be the secondary injury. Problems that can occur and contribute to the ultimate tissue loss after TBI include hypoxia, hypotension, hypovolemia, cerebral ischemia, increased intracranial pressure, hypercapnia, hyperglycemia, seizures and infection[18]. Procedures that prevent and treat these problems can make the difference between recovery to a normal or near-normal condition or permanent disability, and therefore should be initiated without any delay.

Primary trauma survey is the first priority in the head-injured patient. Stabilizing the patient's cervical spine, establishing an adequate airway (A, airway), ensuring adequate ventilation (B, breathing), and gaining venous access to initiate volume resuscitation (C, circulation) are crucial[19]. The primary survey should conclude with determination of the level of consciousness, which represents the most common and reliable clinical parameter used to measure TBI severity[20,21], and examination of the pupils (D, disability). Level of consciousness can be determined using a simple method (AVPU; Alert, responsive to Voice, responsive only to Pain, Unresponsive) or Glasgow Coma Scale (GCS). A GCS score of 15 is considered minor injury, a score of 13 to 14 is considered mild injury, a score of 9 to 12 denotes moderate injury, and finally a score of 3 to 8 indicates severe injury. Repeated GCS recordings are vital because any drop in the score can be a sign of patient's deterioration and requires a search for correctable conditions. Primary survey should be followed by the expeditious transport to a trauma center that has both CT scanning capabilities and neurosurgical service.

The fact that there were no witnesses of the assault on our patient and that the attacker hid her inside the shop, delayed the arrival of the Emergency Medical Team for more than one hour. Upon arrival of the medical team the patient was unconscious, and even after she recovered and was discharged from the hospital had problems recollecting events few hours before and after the attack. Primary survey and initial management in the field were all conducted in accordance to the local policy, which coincides with protocols widely accepted in the Western countries (ABCD approach). All parameters, including GCS score of 3, indicated that the patient had a severe brain injury. Unfortunately, emergency helicopter transportation was not available to the medical team, so a decision had been made to proceed with ambulance car transportation towards the regional trauma center. Ultimately the transportation lasted around four hours, mainly because the accident happened on an island, which relies on ferryboats as the only connection to the mainland.

During transportation a secondary trauma survey was performed. It revealed that, apart from the severe head and brain injuries, our patient sustained extensive faciomaxillary injuries together with a 2$^{nd}$ left hand finger fracture confirmed later on by radiography. Additionally she developed signs of transtentorial herniation, resulting in mannitol being added to the therapy after telephone consultation with a neurosurgeon from the regional trauma center. Prophylactic use of mannitol is not recommended due to its volume-depleting diuretic effect. It should only be used in patients demonstrating signs of transtentorial herniation[22,23], which can have catastrophic consequences, including paralysis, stupor, coma, abnormal heart rhythms, disturbances or cessation of breathing, cardiac arrest, and death. Secondary trauma survey should include a complete neurological examination, as well as the determination of the presence of non-cranial injuries[24]. Around 50% of severely head-injured patients have concomitant, potentially life-threatening injuries[25]. Associated injuries may lead to intravascular volume depletion and heart failure, whereas brainstem injuries can directly affect cardiovascular stability. Furthermore, the association of TBI with multiple injuries in the thoracic or abdominal region, polytraumas, fractures, spinal cord injuries, peripheral nerve injuries, and limb amputations, worsens the prognosis of the patient[25].

Upon arrival to the hospital all patients with loss of consciousness, focal neurogical deficits, clinical signs of basilar or depressed skull fractures, or GCS score of 13 to 14 must undergo urgent CT scanning[26]. CT scan can reveal skull fractures, intracranial hematomas, cerebral contusions and cerebral swelling, and is one of the critical factors in deciding weather to proceed with a neurosurgical procedure. Because of the presence of an epidural hematoma and multiple skull fractures our patient was rushed into surgery. Decompressive craniectomy was performed in which a large area of the left occipitotemporal skull vault was removed, epidural hematoma evacuated, and external ventricular drainage system put in place in order to monitor intracranial pressure (ICP). Although ICP monitoring has become an integral part of the management of patients with severe brain injuries, diverse strategies have been reported in the ICU setting. Management of TBI in intensive care is aimed at optimizing oxygenation, cerebral perfusion, and avoiding secondary insults. There is good evidence to support the protocolized management, which leads to improved outcome after TBI[27,28]. The Brain Trauma Foundation publishes guidelines on the management of severe TBI[29], which are endorsed by the American Association of Neurological Surgeons, the World Health Organization's Committee on Neurotrauma, the Congress of Neurological Surgeons and AANS/CNS Joint Section on Neurotrauma and Critical Care.

Scalp defects due to trauma pose a challenging reconstruction problem, demanding from a surgeon to achieve an acceptable aesthetic result while still allowing optimal functionality. The choice of a particular technique such as local flaps, regional musculocutaneous flaps, skin grafts, free flaps or tissue expansion, depends upon the location and size of the defect as well as the preference of the surgeon. In our patient several plastic surgeries have been performed until adequate results have been achieved. The VAC treatment proved to be a valuable tool in management of our patient's difficult head wound. The VAC represents a controlled application of sub-atmospheric pressure to a wound using a therapy unit, which conveys negative pressure to a specialized wound dressing to help promote wound healing. Andrews and colleagues have also demonstrated that VAC therapy can be successfully used to manage complex wounds in the head and neck region besides those of the torso and extremities[30].

Finally, psychological aspects of TBI, especially when violence is involved, should not be neglected. There are some data pointing that the loss of consciousness during the accident seems to play a protective role with respect to Posttraumatic Stress Disorder (PTSD) development[31]. However, this was not the case with our patient who was unconscious during a long period of time, but still developed PTSD and depression. Psychiatric treatment, as well as family support were crucial in her recovery and resocialization.

## Conclusion

Consequences of TBI are extensive and put a heavy psychosocial and economic burden on the population. TBI presents a great challenge to the medical team as well. It requires multidisciplinary approach and collaboration of specialists from various fields in order to rehabilitate people to the most independent level of functioning possible.


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## TEŠKA TRAUMATSKA OZLJEDA MOZGA NAKON NAPADA DRŠKOM SJEKIRE


### S A Ž E T A K

Traumatske ozljede mozga predstavljaju glavni uzrok smrti i invalidnosti u svijetu. Klinička slika: U radu se prikazuje slučaj pacijentice koja je zadobila teške ozljede mozga nakon napada od strane druge osobe drškom sjekire. Pacijentica je podvrgnuta brojnim operacijama različitih specijalista tijekom razdoblja od nekoliko mjeseci. Nakon neuspješnih pokušaja kirurškog liječenja opsežnih rana glave, upotrebljen je V.A.C. uređaj s vrlo uspješnim ishodom. Traumatske ozljede mozga iziskuju veliki napor i suradnju mnogih stručnjaka, u svrhu što kvalitetnije rehabilitacije pacijenata.