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Anesthetic Management of a Rare Penetrating Traumatic Brain Injury Caused by a Pickaxe: A Case Report

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Abstract

Penetrating traumatic brain injuries (TBI) are frequent neurosurgical emergencies, associated with a high mortality rate and we almost no previous report on a penetrating pickaxe TBI. Herein, we report and discuss the anesthetic challenges encountered in the surgical extraction of a pickaxe from a patient with TBI. We present the case of a 34-year-old man who presented with a penetrating pickaxe TBI at his left temporal region, signs of raised intracranial pressure and normal vital signs. Anesthetic management began within 3 hours of admission and consisted of general anesthesia and rapid sequence intubation. Surgical extraction of a 14 cm long wing of the pickaxe was achieved with good hemostatic control. His postoperative course was marked by complete blindness of the right eye till one year of follow-up. The authors highlight the need of a prompt multidisciplinary management with close perioperative monitoring of haemostatic control and signs of raised intracranial pressure as key factors for a favourable postoperative outcome.

Keywords

Traumatic Brain Injury, Penetrating, Pickaxe, Anesthesia

1. Introduction

Penetrating traumatic brain injury (TBI) is defined as a trauma sustained to the brain by an inanimate projectile object that penetrates the skull, and meninges, and injures the brain parenchyma exposing the cranial vault to the external environment [1]. Penetrating TBI is a neurosurgical emergency which often occurs after road traffic accidents, accidental falls, suicidal attempts, and sharp projectile injuries including gunshots or bomb blasts [2] [3] [4]. Penetrating TBI is amongst the leading causes of mortality and acquired disability in young children and adolescents [5]. It is worth to mention that penetrating TBI accounts for an in-hospital mortality rate of 6.18% in children compared to 23.3% in adults [5]. Hence, penetrating TBI disproportionately affects young male adults [5] [6] [7]. This makes it an occupational disease and raises considerable concerns for the economic impact of the disabilities that may arise in these productive members of society. Survivors of penetrating TBI are at risk of long term complications such as repeated convulsions, posttraumatic stress syndrome, cranial nerve injury, intracranial infection, and abscess formation, leptomeningeal cyst formation, blindness, trauma-induced migraine, hydrocephalus, traumatic aneurysms and arteriovenous malformations, and cognitive dysfunctions [5]. Surgical extraction of the foreign object can be successfully carried out when it is partly impacted to the skull bone but blind removal carries the risk of secondary brain injury [8]. The contemporary literature describes more of the anesthetic management of a penetrating TBI due to nails [2] [3] [9] [10], scissors, screwdrivers, knives, crowbar, spears, bone fragments, rods, chopsticks bullets, ice picks, drills, pencils or pens, pellets, and toothbrushes [1] [8] [11] [12] and little is known about penetrating pickaxe TBI. Herein, we report and discuss the anesthetic challenges encountered in the surgical management of a patient presenting with penetrating pickaxe TBI. This report is the first in Cameroon and perhaps sub-Saharan Africa at large.

2. Case Presentation

A 34-year-old single male Cameroonian presented to the emergency department of the Douala General Hospital after being assaulted by thieves who attempted killing him by pining a pickaxe into his head. The assault occurred in urban Douala, precisely in the patient's house around 2:00 am while he was asleep. He sustained mild bleeding around the side of the injury but had neither loss of consciousness nor motor power. He complained of severe headache, nausea and had three episodes of vomitings before hospital presentation. The patient was rushed to the hospital by a neighbour about an hour following the assault. His past medical, psychosocial and family histories were otherwise normal.

On physical examination, the patient was fully conscious, well oriented in time and space with severe headaches evaluated on a visual analog scale of 8/10. His vital signs were blood pressure (BP) of 132/96 mmHg, pulse rate of 118 beats per minutes, temperature of 37.3˚C, and respiratory rate of 20 breaths per minutes. A penetrating pickaxe wing was visible at the left temporal region with mild blood discharge around it (Figure 1).

He had signs of intracranial pressure (ICP) as evident by headache, three episodes of vomiting and right areactive mydriasis (Figure 2).

No neurological deficit was found. An emergency head CT-scan showed a 13 cm long wing of a pickaxe which had penetrated through the left temporal bone, the left temporal lobe, the frontal lobe and partly into the right temporal lobe of the brain (Figure 3). In view of this, the diagnosis of a penetrating pickaxe TBI was obvious. A laboratory panel requested was normal.

Figure 1. Patient with a penetrating pickaxe at the left fronto-temporal region of the head.

Figure 2. Right areactive mydriasis.

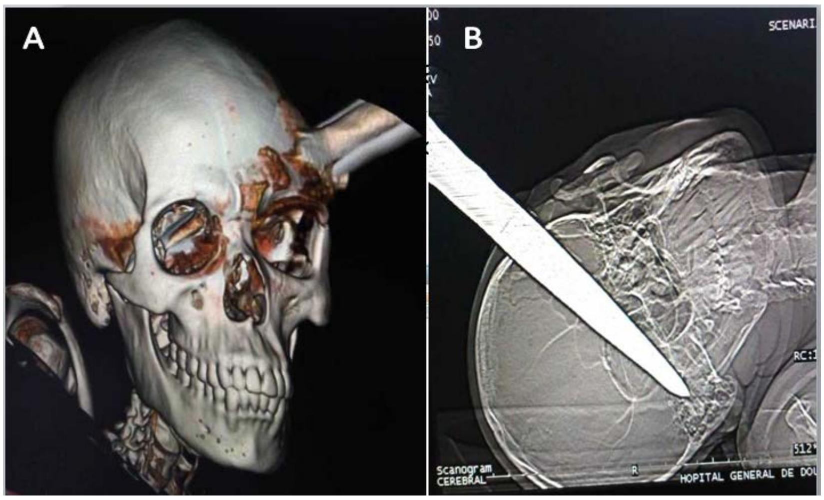

Figure 3. Head CT-Scan showing the penetrating brain injury by the pickaxe. Frontal reconstructive view (A). Coronal reconstructive view (B).

A multidisciplinary team involving neurosurgeons, radiologists and anesthesiologists decided on an emergency surgical extraction of the pickaxe under general anesthesia with orotracheal intubation. Management began with a pre-anesthetic evaluation which was remarkable for an uneventful past history, Mallampati score of 3, a penetrating TBI with signs of raised ICP without signs of brain or cerebral herniation. The anesthetic drugs chosen were fentanyl, propofol, low-MAC isoflurane, and rocuronium bromide for rapid sequence induction and to ease mechanical ventilation. Concerning the intra-operative surveillance we chose to monitor the non-invasive blood pressure, heart rate, respiratory rate, end-expiratory CO_2 concentration ($EtCo_2$), pulse oxygen saturation, temperature, and diuresis. The conclusion of the anesthetic evaluation was $ASA4_E$, Altemeier III.

Preoperative management consisted of placing a 16-Gauge peripheral intravenous line with infusion of 500 ml of normal saline solution, parenteral administration of analgesics (paracetamol 1 g and tramadol 100 mg), broad-spectrum antibiotic therapy (ceftriaxone 50 mg/kg/12h, metronidazole 15 mg/kg/8h and gentamycin 5 mg/kg/24h) and tetanus vaccination. On arrival to the operating room (3 h from admission), his BP was 128/76 mmHg, pulse 99 beats per minutes, and Glasgow coma score (GCS) 15/15. Empirical antibiotic therapy was continued using ceftriaxone 50 mg/kg/12h, metronidazole 15 mg/kg/8h and gentamycin 5 mg/kg/24h to specifically target *Staphylococcus aureus*. Prevention of bleeding was done via administering intravenous tranexamic acid 1 g 30 minutes before surgical incision, then 500 mg hourly via the same route until the end of surgery. The patient was pre-oxygenated for 5 minutes with oxygen at 100%. General anesthesia was administered using rapid sequence induction with intravenous (IV) fentanyl 140 micrograms (2 mcg/kg), propofol 175 mg (2.5 mg/kg) IV and rocuronium bromide 42 mg (0.6 mg/kg). The Cormack-lehane score was 1. The airway was secured with a 7.5 mm internal diameter endotracheal tube which was fixed at 22 cm after bilateral air entry was checked to be equal and adequate. The patient was relayed on controlled volume ventilation. The lungs were ventilated with oxygen: air in 1:2 ratio, a tidal volume of 8/kg, and a with a respiratory rate of 14 breaths per minute. General anesthesia was maintained with inhaled isoflurane between 0.4% to 0.8% volume and intravenous reinjections of propofol and fentanyl and All vital signs including end-expiratory CO_2 concentration were monitored and found normal during surgery. Mean arterial pressure (MAP) was maintained between 50 and 150 mmHg throughout the surgical procedure. The MAP was maintained around 75 mmHg until the complete surgical extraction of the pickaxe (**Figure 4**).

Thereafter, the MAP was maintained at 65 mmHg until hemostasis was achieved. The surgical procedure consisted of a temporal arcuate incision around the pickaxe, followed by widening of the point of entry of the pickaxe with a surgical curate. This enabled the extraction of the pickaxe following its axis in a single jerk. Overall, the tip of the pickaxe of about 14 cm long was extracted leaving a cavity of about 4 cm diameter in the cerebral parenchyma. Hemostasis was achieved with a bipolar forceps, followed by compression with surgicel. Then, the surgical area was washed with normal saline. Thereafter, a duroplasty was performed. The closure was done plan by plan with absorbable sutures (**Figure 5**). The patient was extubated on the operating table after demonstrating haemodynamic stability, spontaneous ventilation at a saturation of 99% at room air, and full awakeness with visual pursuit and swallowing reflex present. Postoperative analgesia began 30 mins before the end of surgery using IV paracetamol 1 g, IV tramadol 100 mg and IV nefopam 20 mg. Endotracheal extubation was done on the operation table. The duration of the surgery was 2 hours and that of general anesthesia was 2 h 15 mins. Overall, the patient received 1600 ml of normal saline intraoperatively; with an estimated blood loss of 150 ml and urine output of 400 ml. There was no incident during the intervention. Thereafter, the patient was transferred to the intensive care unit for postoperative monitoring and management.

Figure 4. Completely surgically extracted pickaxe.

Figure 5. Skin closure after extraction of the pickaxe.

In the intensive care unit his postoperative management entailed hydration (30 ml/kg/24h of normal saline), IV analgesics (nefopam 20 mg/6h and paracetamol 1 g/6h), IV antibiotic therapy (ceftriaxone 50 mg/kg/12h, metronidazole 15 mg/kg/8h and gentamycin 5 mg/kg/24h), prevention of thromboembolic disease (via the wearing of compression stockings and subcutaneous enoxaparin 40 mg/24h administered at the 12th hour after surgery), and prevention of stress ulcer (IV omeprazole 40 mg/24h). Enteral nutrition with oral intake of 25 kcal/24h was started at six hours following surgery. Regular vital signs monitoring included the level of consciousness (GCS), non-invasive BP, heart rate, respiratory rate, pulse oxygen saturation, hourly diuresis, pain (assessed through the visual analog scale), and blood glucose. His postoperative course at day one was remarkable for the blindness of the right eye. However, he had a good general state, a full level of conscious, hemodynamic stability, and disappearance of signs of raised ICP. The patient was transferred to the department of neurosurgery on the 2nd postoperative day in a good general state but with persistent unilateral blindness. He was discharged home on day five postoperation with persistent unilateral blindness for which an ophthalmologist consult was requested. The ophthalmologist's diagnosis was an irreversible right optic nerve lesion with resultant blindness caused by the penetrating TBI. His follow-up at one year was remarkable for persistent blindness of the right eye. Thereafter, the patient was lost to follow up.

3. Discussion

There is scarce data on the anesthetic challenges encountered in the surgical management of a penetrating TBI caused by the wing of a pickaxe of this magnitude (14 cm long). Furthermore, the fact that the ax had a really large sharp blade, penetrated quite deep into the brain parenchyma and caused only blindness is significant for the fact that no other brain lesion was caused.

Penetrating TBI is a major public health problem [13]. According to global statistics, the annual incidence of TBI is 700 per 100,000 [14] and mortality rate due to TBI is about 17 per 100,000 [15] [16]. In the United States TBI affects about 1.7 million people per year and accounts for 52,000 deaths annually [7]. More than 30,000 Polish die each year from TBI. This is two-fold higher than that observed in the Netherlands. Sadly, in Hungary and France, more people have a fatal outcome from TBI than in Poland [15]. In a previous report at the General Hospital of Douala in Cameroon, the in-hospital prevalence of TBI was 8.7% [6].

Given the aforementioned mortality rates, TBI is an emergency that requires prompt preoperative management and surgical intervention like similar surgical emergencies [17]. Following a penetrating TBI, adequate pre-hospital care geared at patient stabilization and securing the penetrated object to prevent further brain injury is crucial [9]. An assessment of the presence of a neurological deficit is important before any surgical intervention to remove the penetrating object

[5]. As seen in the indexed patient, the penetrating object did not cause intracranial bleeding at the time of TBI occurs due to a tamponade effect. Haemorrhage tends to occur once the tamponade effect ceases to act during surgical extraction of the foreign object [18]. Minimal blood lot was observed in the present case. A plausible explanation to this may the intravenous administration of tranexamic acid prior and continuously during surgery. This finding concurs with that of a recent systematic review which demonstrated the efficacy of tranexamic acid in reducing intracranial haemorrhage in TBI patients [19].

The following considerations need to be taken into account in the anesthetic management of a penetrating TBI. Firstly, the raised ICP due to the compression of the cerebral parenchyma leads to the occurrence of new cerebral lesions like peri-lesional cerebral oedema and these further increases the ICP. During general anaesthesia the objective is to maintain a normal ICP and a cerebral perfusion pressure between 50 and 150 mmHg for an adequate cerebral perfusion pressure [20]. Secondly, surgical blood loses and anesthetic drugs further predispose patients with TBI to hypotension. Here, prevention and correction of hypotension, hyper-or-hypoglycemia, hypo-or-hyperthermia, hypoxia, hypercapnia during mechanical ventilation are the main objectives during the perioperative management of penetrating TBI, geared at preventing secondary brain injuries [21]. Hence, perioperatively, both invasive and non-invasive blood pressure, pulse oximetry, capnography, urine output, arterial blood gas analysis, blood glucose, temperature, and electrocardiogram monitoring are important [9]. Thirdly, airway control often poses a considerable problem in patients with TBI as the pickaxe or any other foreign object may be oriented in a way which obstructs endotracheal intubation, and the ax only needs to be cut to gain access to the airways [22]. Furthermore, unless a cervical spine CT-scan is performed, the general assumption is that every patient with TBI has a potential cervical spinal injury which needs to be managed with neck stabilization [22]. Also, the risk of cervical spine injury poses a dilemma of hyperextension of the neck which risks aggravating the cervical spinal lesion or risks blocking the neck in case the temporo-mandibular joint may be heavy due to the presence of the foreign object like the pickaxe of about 7 kg in the above case [22]. This leads to a risk of difficult endotracheal intubation [20]. In the same vein, the communication of the cerebral parenchyma with the external environment, as well as the intracranial presence of a foreign body such as the rusty pickaxe in the indexed case predisposes the patient to a risk of central nervous infection [20]. Moreover, a patient with a penetrating TBI is considered to have a full stomach given that the surgery is often done in an emergency setting and with no respect for preoperative fasting [20]. The full stomach potentiates the risk of inhalation during laryngoscopy. These all required rapid patient care [20]. More still, the problems posed by the surgery are those of an emergency cranial surgery carried out in the supine position and of intermediate duration. In addition, the surgery poses the problems of conflict of sites between the surgical team and the anesthetists. Furthermore, it is a potentially hemorrhagic surgery, painful, potentially thromboembolic and requiring no myorelaxation. Also, anesthesia poses the problem of the choice of the type of technique of anesthesia which is general anesthesia with orotracheal intubation as the mainstay technique. Adequate intraoperative and postoperative analgesia is essential, as any noxious stimuli may cause a sympathetic surge increasing cerebral blood flow, cerebral oxygen consumption, and ICP [9]. All volatile hypnotics at MAC below 1, usually reduces cerebral oxygen consumption and lead to cerebral vasodilation with resultant increase cerebral blood flow which furthers increases ICP [9]. In this regards, sevoflurane below 1 MAC is best suited for neurosurgical interventions [9]. However, due to its scarcity and relatively high financial cost in our resource-limited setting, sevoflurane was not available at the time of management of this patient. Propofol is considered as the best IV hypnotics for TBI surgery despite its ability to reduce cerebral perfusion [9]. Midazolam is a good adjuvant to IV hypnotics [22]. Ketamine which used to be refuted for its effect in raising cerebral blood flow and cerebral metabolic needs in oxygen has recently been considered an IV hypnotic option, as long as it is administered with another hypnotic agent, preferably propofol and at moderate doses (0.6 - 1 mg/kg, as a slow intravenous bolus) [23]. Rocuronium appears to be the safest neuromuscular blocking drug in neuroanaesthesia due to its minimal cardiovascular effects, the possibility of doing a rapid sequence induction and no histamine releasing-property [9]. Succinylcholine is another alternative to rocuronium but poses the problems of a slight and transient rise in ICP and histamine liberation [24]. Remifentanil or fentanyl are indicated for analgesia and to help potentiate the effect of hypnotics in neuroanaesthesia [22]. Furthermore, there has been an ongoing debate on whether to extubate TBI patients early (within 7 days) versus late (after 7 days) [25] [26]. Pros for early extubation argue that this reduces the risk of ventilator-associated pneumonia while cons argue that early extubation is associated with extubation failure, raised ICP and residual intracerebral bleeding [26]. A recent good quality multicenter cohort study found that criteria predictive of a successful extubation in severe brain injury patients were visual pursuit, swallowing, GCS > 8 and age < 40 years [27]. The above case portrayed all these criteria of successful early extubation, hence, was extubated on the operating table without complications.

The prognosis of a penetrating TBI is dependent on the velocity of the injury [9]. The low velocity of pickaxe penetrating TBI compared to gunshots injuries implied a good prognosis in the above case. Furthermore, the fact that the patient was perfectly conscious on arrival, without any focal sign was another good prognostic factor. If there had been cerebrovascular injury and/or ischemia, one would have expected a transient, prolonged or permanent alteration of his level of consciousness. The absence of hypodensity or hyperdensity within the vascular territories of his CT-scan was an argument in favour of this. Also, the absence of hypotension, hypoxia, and hypercapnia as aforementioned [21] were equally vital in determining our patient's favourable outcome.

Survivors of TBI often require long-term management and rehabilitation [15].

Because of its location, penetrating TBI can cause central nervous system damage and life-threatening conditions. In addition, these lesions can damage large cerebral vessels, the brainstem and cause obstruction of the upper respiratory tract [15] [28]. Our patient with a pickaxe of about 7 kg stuck in his brain had a good general condition and was fully conscious. His sole complication was the blindness of the right eye secondary to an irreversible lesion to the right optic nerve caused by prolonged compression or ischaemia by the pickaxe. This observation corroborates with previous reports [5].

4. Conclusion

We have reported the first case of anesthetic challenges encountered in the surgical management of a rare neurosurgical emergency caused by a penetrating pickaxe TBI in Cameroon and perhaps sub-Saharan Africa at large. Through this report the authors wish to draw anesthesiologists of the feasibility of this management even in resource-challenged settings. Furthermore, it is paramount to highlight the need of a prompt multidisciplinary management with close perioperative monitoring of haemostatic control and signs of raised intracranial pressure as key factors for a favourable postoperative outcome.

Conflicts of Interest

The authors declare that they have no competing interests.

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