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Case Report

Multidisciplinary management of a penetrating cerebellar injury by a fishing speargun: A case study and literature review

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ABSTRACT

Background: Fishing spearguns are a rare cause of nonmissile penetrating brain injuries (PBIs). Discussion of their injury patterns and treatments has been published only sporadically. Here, we report a case of a self-inflicted PBI caused by this type of weapon and present an extensive review of previous case reports to help ascertain the appropriate surgical approach.

Case Description: A 26-year-old man with a preexisting psychiatric illness was transferred to our hospital after a self-inflicted shot with a fishing speargun through his mouth. The ensuing injuries included the impalement of a spear intracranially through the soft palate and posterior oropharyngeal wall. The spear was surgically accessed by the otolaryngology team by splitting the soft palate and was removed by the neurosurgery team in the retrograde direction. Cerebral angiographies were done pre- and postoperatively, and these did not detect any vertebrobasilar arterial system injuries. The patient's postoperative care was uneventful, and he was followed up by a psychiatrist for his long-term care.

Conclusion: This example of a complicated case of nonmissile PBI caused by an uncommon type of weapon shows how this type of medical emergency can be managed successfully with effective teamwork using a multidisciplinary approach.

Keywords: Foreign body, Harpoon, Neurotrauma, Penetrating brain injury, Systematic review

INTRODUCTION

Penetrating brain injury (PBI) is serious, with a high mortality and morbidity rate.[24] PBI is mostly caused by firearms or warfare weapons. Nonmissile injuries are a rare type of PBI caused by low-velocity weapons, including knives, nails, wooden handles, iron rods, or fishing spearguns.[18] These PBIs are associated with either no blast effect or a lower blast effect compared with missile injuries and have no kinetic energy or cavitation effects. Moreover, this type of PBI often has limited effects along the weapon's trajectory, in addition to lower severity.[17]

Intracranial injuries due to a fishing speargun or harpoon are rare. In the past, injuries from such weapons were often accidental[7] and typically occurred while fishing or preparing fishing equipment.[27] Such accidents usually affect the facial[2] or frontal regions,[26] resulting in a low mortality rate. However, an increasing trend in the number of cases of self-inflicted injuries has been observed; these have varying injury patterns and a higher mortality rate.[5,28]

This report discusses the case of a patient who attempted suicide with a fishing speargun and sustained an infratentorial injury. Moreover, we review previous case reports of PBIs using this weapon to analyze and summarize the most effective treatment strategy for the optimal management of this type of injury.

CASE DESCRIPTION

This case involved a 26-year-old man who was being treated for a psychiatric disorder. On the day of presentation, his relatives found him lying on the bedroom floor. There was a speargun rod in his mouth, and he was bleeding, including from his nose. On inquiring the history, we learned that the patient had shot himself with a rubber band speargun. At the scene, the patient was conscious and showed no weakness; hence, the relatives took him to the nearest community hospital.

According to the patient's treatment history at that hospital, the spear was cut short, just approximately 10 cm off the edge of the patient's lips. He was calm, breathed well, and had normal vital signs without any neurological deficits. The patient received oxygen through a nasal cannula and was administered tetanus toxoid and intravenous antibiotics. In addition, he underwent cranial X-ray [Figure 1] and was later referred to a level I trauma center.

At our hospital, a multidisciplinary team of neurosurgeons, trauma surgeons, otolaryngologists, interventional neurologists, and anesthesiologists was established urgently to assess the patient. Initially, the patient's vital signs and symptoms were normal. In addition, no bleeding was observed in the upper aerodigestive tract. On physical examination, an 8 mm diameter round iron spear was found to have penetrated through his soft palate and the posterior oropharyngeal wall.

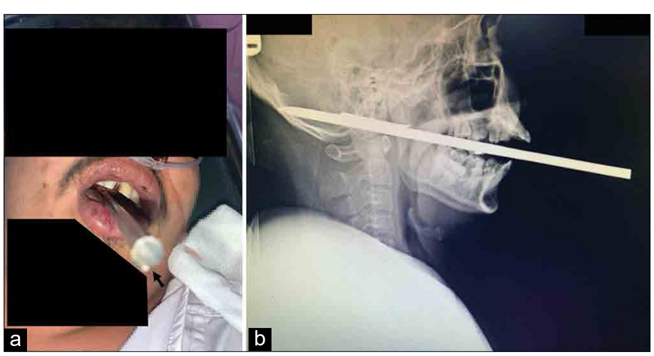

Figure 1: (a) A photograph of the patient with the metal spear (arrow) entering through the oral cavity with contact epistaxis. (b) Lateral view of a plain film of skull showing the spear, flapper tip type, entering through the oral cavity into the posterior fossa.

Cranial computed tomography (CT) scan showed a metallic rod that had penetrated through the oropharynx, the left side of the clivus, and the left lateral part of the posterior fossa. The rod was positioned slightly above the foramen magnum and ended in the left cerebellar hemisphere. The spear's tip was located at the inner cortex of the left side of the occipital bone [Figure 2a-g]. Moreover, multiple pneumocephali and pneumoventricles were observed. However, no intracerebellar hemorrhage was observed [Figure 2h].

Three-dimensional (3D) CT reconstruction images revealed the details of the spear; it had a harpoon (or flapper), with the most convex part of the metallic tip of the spear acting as a hinge. This section was located within the clivus bone, with the end of the flapper having partially penetrated the intracranial cavity [Figure 3a and b]. CT angiography (CTA) was performed to evaluate vascular injuries because the spear appeared to be located near the vertebrobasilar junction. However, there were multiple metallic artifacts obscuring the surrounding vessels [Figure 3c and d]. After discussion among the multidisciplinary medical team members, relatives, and the patient, it was decided that the patient should undergo surgery. The surgery was performed in a hybrid operating room, which had a combination of equipment for digital subtraction cerebral angiography (DSA) as well as endovascular treatment and surgery.

Treatment began with airway management. The patient could open his mouth only one finger wide. Therefore, the anesthesiologist performed nasotracheal intubation using the awake fiber-optic technique during which the patient cooperated well [Figure 4]. Next, diagnostic cerebral angiography was performed to completely evaluate the vessels; it revealed that the left vertebral artery was located adjacent to the spear, with no signs of a false aneurysm or luminal narrowing. The other intracranial arteries, including the anterior and posterior circulations near the spear, were unobstructed [Figure 5a and b]. Then, a guiding catheter with a continuous slow rate saline drip was placed into the left proximal vertebral artery so as to prepare for a repeated angiogram and embolization in case of an arterial extravasation or secondary tearing during or immediately after removal of the spear.

Otolaryngologists operated on the patient starting with a tracheostomy because the nasotracheal tube obstructed the surgical spear removal path. Then, the surgeon opened the patient's mouth with a Dingman retractor and separated the soft palate as well as the posterior pharyngeal wall at the median. The neurosurgery team further exposed the soft tissue surrounding the spear until the end of the flapper could be located. Under a microscope, the team members

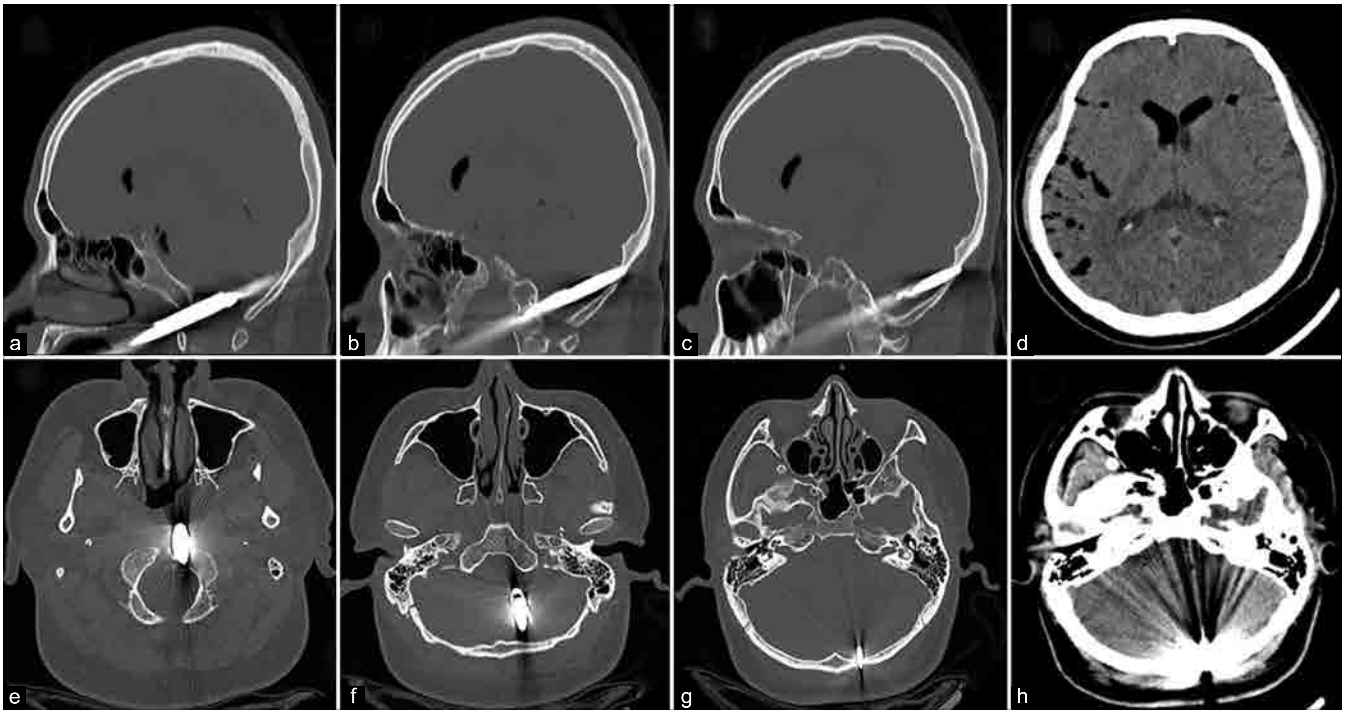

Figure 2: Cranial computed tomography (CT). Sagittal views (a-c) and axial views (e-g) of bone window showing the spear trajectory – entrance, path, and end of spear tip. Axial views of plain CT, soft-tissue window showing multiple pneumocephali along cerebral sulci and pneumoventricles in the frontal horns of lateral ventricles (d). No cerebellar hemorrhage observed (h).

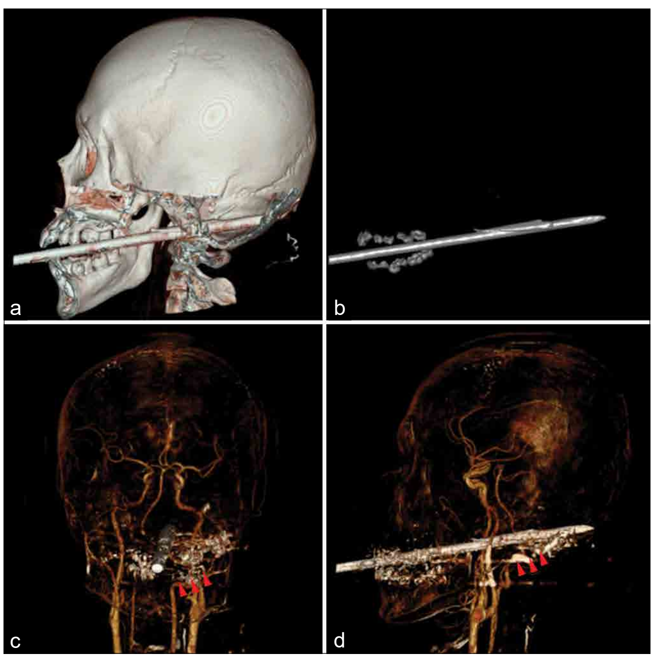

Figure 3: (a) Cranial 3D computed tomography scan (3D-CT), lateral view, demonstrating the spear direction passing the clivus to the occipital bone. (b) The spear characteristics were revealed after subtracting skull out corresponding with "one-flapper type" of spear's tips. (c and d) Computed tomography angiography reconstruction on AP (c) and lateral (d) views revealing the trajectory of the spear is close to the left vertebral artery with multiple metallic artifacts (head arrows).

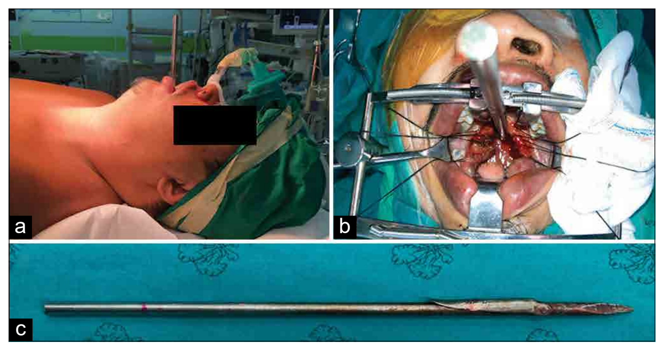

Figure 4: Intraoperative photographs showing (a) the patient position after fiber-optic intubation, and (b) the application of the Dingman mouth retractor to open the patient's mouth and the splitting of the soft palate. The spear is shown entering the posterior oropharyngeal wall. (c) Photograph showing the spear after removal; it had a one flapper (harpoon) tip and was 26 cm in length.

then drilled the clivus bone that surrounded and covered the flapper. When the spear was gently pulled out, slight bleeding occurred from the clivus bone, which was successfully stopped using bone wax.

There was fortunately no continuous intracranial bleeding. A thorough rinsing was performed with a large amount of saline solution, and all visible bleedings were coagulated. Then, the dural defect was repaired with a dural substitute and tissue sealant. Finally, the posterior pharynx was closed tightly; the soft palate was repaired and reapproximated.

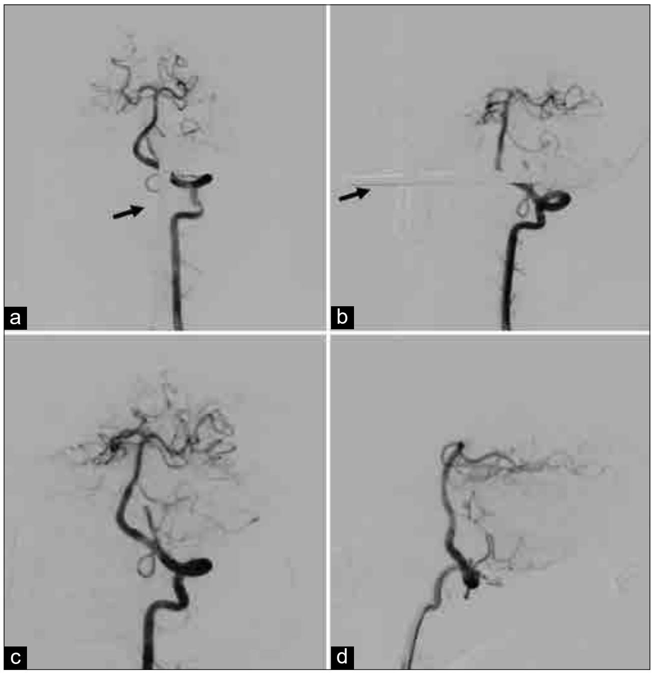

Figure 5: Diagnostic digital subtraction angiography (DSA) demonstrating a normal left vertebral artery located just adjacent to the spear on anterior-posterior (AP) (a) and oblique views (b). A 3D DSA was subsequently done and confirm no visualized injuries of the left vertebral artery and surrounding vessels (not shown). The arrow is pointing the spear abutting the left vertebral artery before removal (a and b). The AP (c) and lateral views (d) of a left vertebral angiography after spear removal showing normal vessels without secondary false aneurysms or developed extravasations.

After removing the spear, angiographic findings concerning the intracranial arteries were found to be normal, both immediately [Figure 5c and d] and 2 weeks postoperatively. In the postoperative period, the patient's respiratory function was normal and the tracheostomy tube was subsequently removed. The patient started breathing naturally.

The patient also underwent psychiatric evaluation and was diagnosed with adjustment disorder, which was treated with medications and emotional support. He was finally discharged on postoperative day 19. His mental state was normal, and he no longer had any suicidal ideation.

DISCUSSION

The patient had a good outcome because of the effectively planned treatment by the interdisciplinary medical team and the appropriate use of the available medical resources.

Fishing spearguns are a cause of nonmissile PBIs. The first such case was reported by Paillas and Legre in 1956.[23] A few subsequent studies have reported other cases with a wide variety of injury characteristics and treatments. Hence, no clear management guidelines have been established.

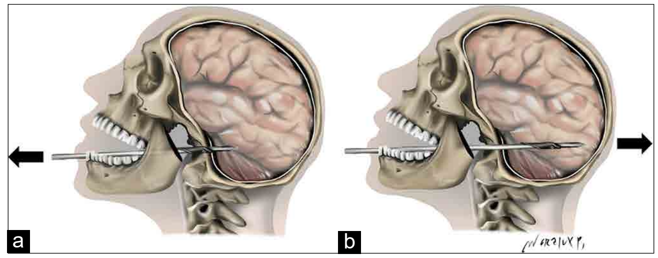

Figure 6: The proposed direction of spear removal in a flapper type speargun injury. (a) The flapper is embedded within the skull base. The authors suggest removing the spear in a retrograde direction (arrow). (b) The flapper is embedded within the intracranial compartment. The authors suggest removing the spear in an anterograde direction (arrow).

To provide a better quality of care for those injured from this type of weapon, we searched the PubMed database from 1977 until May 2021 for fishing speargun injuries using the search terms "fishing," "speargun," "harpoon," "trauma," and "brain injury," which were combined in various ways using the "OR" and "AND" search strategy. We included studies published in all languages. A citation within relevant articles was also further reviewed. However, studies with postmortem and forensic studies[6,9,22] were excluded from the study. The initial search result yielded 107 results. A total of 18 full-text articles were finally retrieved, which involved a total of 21 patients. Table 1 summarizes these findings.[1,3-5,10-14,16,19,23,25-28]

Most of these injuries occur in males between the ages of 6 and 55 years, and the most common cause is an accident occurring while fishing. The second most common cause is suicide attempts.[1,3-5,28] The two causes tend to have different entrance positions and spear trajectories. In accidental injuries, the spear usually enters in the intracranial cavity from the frontal or occipital region and has a front-to-back trajectory. In suicide attempts, the spear usually enters from the submental or submandibular region of the oral cavity and the trajectory is either caudal to cephalad or front to back.

For surgical planning, spear trajectory, injured organs (e.g., brain and blood vessels), and spear tip characteristics and position are important aspects that need to be considered. In addition, concomitant injuries and the patient's preinjury health status should be taken into account.

The spear trajectory is directly related to the location of the brain injury. Locations that are near major arteries or venous sinuses increase the risk of vascular injury.[7] Fortunately, the force of action that occurs around the spear is usually limited to the spear position. Because this type of injury is low speed, no other ballistic effects are typically found.[17,18]

According to the PBI guidelines,[21] CT scans are recommended in all cases. Moreover, patients at risk for major vascular injuries should be further examined by CTA. In the current case, the line of the spear pitched through the oral

Table 1:. Reported Cases of Penetrating Head Injuries Caused by Spearguns

Studies	Age (years)/Sex	Cause	Imaging	Type of spear tip	Entry point	Spear tip location	Location of flapper (if present)	Surgical approach	Direction of spear removal	Complication/Event	Outcome	Follow-up time (months)
Paillas et al., 1956[23]	13/M	Accident	Skull films	Flapper	R Orbit	Ext, R occipital	Int	Occipital craniectomy	Anterograde	-	L hemiplegia, L hemianesthesia	2
Giani, 1960[12]	14/M	Not clear	Skull films	Trident (one prong)	Frontal region	Int, L frontal lobe	-	Not clear	Not clear	None	No neurological deficit	10 days
Chadduck, 1969[7]	6/F	Accident	Skull films, Angiogram (later)	Barb	R frontal region	Int, R frontal lobe	-	Frontal craniectomy	Retrograde	Ruptured false MCA aneurysm	Facial palsy	1
Doron et al., 1982[10]	20/M	Accident	Skull films	Trident (three prongs)	Both orbits and mid-frontal region	Int, bifrontal lobes	Int	L frontal craniotomy, R frontal craniectomy	Retrograde	Subdural and intracerebral hemorrhage	Died	3 days
Gutierres et al., 1983[14]	29/M	Accident	Skull films	Flapper	L nose	Int, L parietal lobe	Int	Parietal craniectomy	Anterograde	None	No neurological deficit	6
Rocca et al., 1987[26]	12/M	Accident	Skull films	Trident (three prongs)	R frontal region	Int, R frontal lobe (two prongs) and one prong Ext.	-	R fronto-temporal craniotomy	Anterograde	None	No neurological deficit	Not reported
	11/M	Accident	Skull films	Trident (one prong)	R orbit	Int, R frontal lobe	-	R fronto-temporal craniotomy	Anterograde	Seizure	No neurological deficit	10 days
Gil et al., 1998[13]	29/M	Accident	Skull films	Flapper	R preauricular area	Int, L frontal lobe	Int	Bifrontal craniotomy	Anterograde	None	No neurological deficit	8 days
	33/M	Accident	Skull films	Flapper	R frontotemporal region	Int, L frontal lobe	Int	Frontal craniectomy	Anterograde	None	No neurological deficit	10 days
	31/M	Accident	Skull films	Flapper	R frontal region	Ext. through L temporal bone	Ext	R frontal, L temporal craniectomy	Anterograde	None	No neurological deficit	13 days
López et al., 2000[19]	6/F	Accident	Skull films, Cranial CT	Flapper	R frontal region	Ext. through R occipital bone	Int	Occipital craniectomy	Anterograde	None	R arm paresis	12

(Contd...)

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Studies	Age (years)/Sex	Cause	Imaging	Type of spear tip	Entry point	Spear tip location	Location of flapper (if present)	Surgical approach	Direction of spear removal	Complication/Event	Outcome	Follow-up time (months)
Fernández-Melo et al., 2002[11]	31/M	Accident	Skull films, Cranial CT	Flapper	R frontal region	Ext. through L temporal bone	Ext	R frontal, L temporal craniectomy	Anterograde	None	No neurological deficit	6
Ban et al., 2008[4]	43/M	Suicide	Cranial CT	Flapper	Oral cavity	Ext. through L occipital bone	Int	Occipital craniectomy	Anterograde	None	L facial palsy, cerebellar function deficit	7 days
Abarca-Olivas, 2011[1]	34/M	Suicide	Cranial CT	Flapper	Submental area	Ext. through R coronal suture	Int	Frontoparietal craniotomy	Anterograde	None	No neurological deficit	6
Williams et al., 2014[28]	55/M	Suicide	Cranial CT, 3D-CT	Flapper	Submandibular area	Ext. through L parietal bone	Embedded in L parietal bone	Parietal craniectomy	Anterograde	Cerebritis	Died	1
Bakhos et al., 2015[3]	35/M	Suicide	Cranial CT	Flapper	Submental area	Int, midline frontal region	Embedded in cribriform plate	Pull out from submental area	Retrograde	None	No neurological deficit	36
Veiga San Román et al., 2015[27]	30/M	Accident	Skull films, Cranial CT, 3D-CT	Flapper (spring)	Submandibular area	Int, R temporal lobe	Ext, adjacent to the L mandibular condyle	Transoral	Retrograde	None	Conductive hearing deficit	1
Peligero Deza et al., 2016[25]	27/M	Accident	Cranial CT, 3D-CT	Flapper	Submental area	Ext. through R frontal bone	Int	Pull out cephalad	Anterograde	None	No neurological deficit	3 days
Júnior et al., 2018[16]	32/M	Accident	Cranial CT, 3D-CT	Flapper	L occipital region	Int, L occipital lobe	Ext	Occipital craniectomy	Retrograde	None	No neurological deficit	5 days
Barranco et al., 2020[5]	59/M	Suicide	Skull films, Cranial CT, 3D-CT	Flapper	Oral cavity	Int, L parietal lobe	Int	Transoral	Retrograde	Massive and unstoppable intracranial hemorrhage	Died	2
Current study	26/M	Suicide	Skull films, Cranial CT, 3D-CT, DSA	Flapper	Oral cavity	Int, L occipital lobe	Embedded in clivus	Transoral	Retrograde	None	No neurological deficit	19 days

3D-CT, 3-dimensional computed tomography reconstruction; CT, computed tomography; DSA, digital subtraction angiography; Ext, extracranial; F, female; Int, intracranial; L, left; M, male; R, right.

cavity and clivus bone into the posterior cranial fossa. That trajectory can injure the vertebrobasilar junction, and CTA showed some limitations in assessing this structure due to the presence of metallic artifacts. Harrington *et al*. evaluated 192 nonmissile PBI cases[15] and proposed a management algorithm that recommends that patients with an object *in situ* and at a high risk for vascular injury (large intracerebral hemorrhage, transorbital injury, tract near a major vessel, and penetration depth > 4 cm) should undergo DSA under general anesthesia instead of CTA. They further suggested that the objects be removed in an angiogram suite and that DSA be repeated immediately after removal.

Studying the composition of weapons is an important issue in surgical planning involving such cases, particularly the spear tip characteristics. In general, there are two types of spears – single rods and tridents. The tip of a single rod spear is generally attached to a hinged device called a *harpoon* or *flapper tip*, which may have 1–2 flappers; in some cases, it can have a spring flapper. A trident has three prongs that usually have no hinges, and the tips of the prongs have barbs.[20] The spear tip characteristics can be assessed using 3D CT reconstruction, which is commonly used today.[5,16,25,27,28]

We propose a surgical approach guided by the type of spear tip and its location. For barbed tips, the spear can be pulled out either in line with the trajectory, that is, in the anterograde direction or in the opposite line of the trajectory, that is, in the retrograde direction. In addition to the position of the tip's end, the direction of removal depends on the closeness of the tip to the surface of the adjacent cortex. In the case of flapper tips, the flapper is characterized by a hinge that can be unfolded when a substantial amount of tissue is blocking the flapper end; it is designed in this manner to prevent the fish escaping from the spear while fishing. The flapper position is an important point, particularly for cases in which the flapper is entirely intracranial or penetrates outside the cranium. Therefore, it is recommended to pull the spear out in the anterograde direction because pulling the spear in the retrograde direction can cause the flapper to spread and cause further brain parenchymal tearing.[5] However, in cases when the flapper is embedded at the base of the skull, such as in the present case, the spear can be safely pulled out in the retrograde direction [Figure 6]. We advocated this strategy from our experiences and literature review. However, every injury of such type will be unique, and its management should be tailored to the case at hand.

Antibiotics and antiepileptic drug treatments were used in most previous reports. However, varied practices were followed regarding the choice of drugs, their dosage, and duration of use.

With respect to airway management, procedures to secure airway should be planned thoroughly as a team approach, which comprised anesthesiologists and otolaryngologists in the present case. Instruments involving airway procedures should be prompt in diminishing the risk of airway loss, which can prove fatal. At least one or more back up plans for airway retrieval should be prepared for patient safety.

Finally, assessing mental status and providing adequate treatment for the underlying medical problems of suicide survivors are important for enhancing both the patient's quality of life and ongoing care.[8]

CONCLUSION

The management of nonmissile PBI is challenging due to unfamiliarity with this type of injury because of its rarity and the fact that it involves both the intracranial and extracranial organs. When the fishing speargun is used as a weapon for suicide, it is associated with high mortality. In such cases, surgical planning for foreign body removal is critical. This planning depends on the injured organs, spear trajectory, and the type and position of the spear tip. A multidisciplinary team is required to overcome the challenges posed by this unique emergency.

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Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

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