Outcome of Penetrating Brain Injury in Civilian Practice

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Abstract

Introduction There is a dramatic increase in the incidence and little is known about outcome and recovery of penetrating brain injuries. Our study is based on analysis of clinical-radiological profile and outcome of patients of penetrating brain injuries.

Method This is a retrospective analysis of patients with penetrating head injury during the period from June 2004 to May 2013. Patients with penetrating head injury were selected from our hospital record. Their operative findings were evaluated and only those patients with documented penetration of the dura by a foreign material were selected for data collection and analysis.

Results A total of 60 patients were recruited in the study. Their mean age was 27 years, and most patients were male. Most common clinical presentation was brain matter and cerebrospinal fluid (CSF) leak in 48 (60%) patients followed by decreased level of consciousness in 40 (66.67%) patients. Frontal lobe was most commonly involved part in 24 (40%) patients followed by multiple lobe injury noted in 16 (26.66%) patients. Twelve patients expired during the hospital stay. Thirteen patients were discharged in GOS-2, 15 in GOS-3, and 20 in GOS-4. Wound infection occurred in 11 (18.33%) patients, and seizure developed in 8 (13.33%) patients.

Conclusion Penetrating brain injuries are most common in 11- to 30-year-old age group and occur more commonly in male. Most common presentations were brain matter or CSF leak and most common mode of injury was firearm. Frontal lobe was the most commonly injured part of the brain and mortality was 20%. Higher mortality was observed among patients with seizure than in other patients with penetrating brain injury.

Keywords
- ► penetrating
- ► civilian
- ► head injury

A penetrating head injury is a wound in which a projectile breaches the cranium but does not exit. In the past 20 years, the world, including India, has witnessed a dramatic increase in the incidence of penetrating injuries to the brain due to increasing use of firearms and weapons.[1,2]

Whereas outcome and recovery following nonpenetrating brain injury is a topic that has been researched extensively, little is known about outcome and recovery of penetrating brain injuries, particularly, in nonmilitary, or civilian populations. Most individuals sustaining a penetrating traumatic brain injury (TBI) usually do not survive. Some civilian studies report mortality rates as high as 93%, with most deaths occurring at the accident scene, in transit, or shortly after reaching an intensive care unit (ICU).[3,4]

Patients who survive penetrating craniocerebral injuries are at risk of experiencing multiple complications, including

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persistent neurologic deficits, infections, epilepsy, CSF leak, cranial nerve deficits, pseudoaneurysms, arteriovenous fistulas, and hydrocephalus.

Computed tomography (CT) is routinely used for diagnosis and management of penetrating brain injuries. It helps in localization and identification of intracranial hematoma, contusion, foreign bodies, pneumocephalus, depressed fracture, and cerebral edema.

Intraoperative ultrasound is an easy, safe, and noninvasive technique, used for localization of hematoma, injured area, wound tract, and also helps in removal of foreign bodies from brain parenchyma. Recently, real-time contrast-enhanced ultrasound (CEUS) has been used for visualizing change in microcirculation and perfusion of tissue, thus distinguishing necrotic tissue in injured area from normal brain parenchyma.[5]

Aggressive ICU care management in combination with early management with less aggressive, meticulous, neurosurgical technique, when appropriate, already has significantly reduced the mortality and morbidity associated with these injuries, but they still remain unacceptably high.[6]

We at our institute attend to large number of patients with head injury, many of whom suffer with penetrating brain injury. On literature search, we could find only few articles from India on this subject. Therefore, we planned to report our experience about managing 60 patients with penetrating brain injury in the past 10 years.

Materials and Methods

The current study was undertaken at Department of Neurosurgery, King George's Medical University, Lucknow, UP, India, by retrospective analysis of patients with penetrating head injury during the period June 2004 to May 2013 (10 years). Records of all patients admitted with diagnosis of penetrating head injury were taken out. Their operative findings were evaluated and only the patients with documented penetration of the dura by a foreign material were selected for data collection and analysis. Thus 60 patients were enrolled for the study.

Exclusion criteria included (1) injury without penetration of dura, (2) compound or comminuted fractures with dural tear and brain matter leak, (3) dural tear by penetration of bone piece or bony spur, and (4) patients operated elsewhere for penetrating brain injury and latter admitted with us for management of complications.

According to protocol in our hospital, patients were admitted and their primary management included stabilization of hemodynamics and upper airway. Antibiotics, antiepileptic, cerebral dehydrants, IV fluids, and supportive care were given according to requirement. Patients were subjected to noncontrast preoperative CT scan of the head. Antiepileptics were given for 6 month in all patients and continued according to requirements. All patients were evaluated at the time of discharge using Glasgow Outcome Scale (GCS). Patients' GCS and Glasgow Outcome Scale were noted at 1 and 6 months from follow-up records.

Results

Age and sex We recruited 60 persons sustaining a penetrating TBI regardless of the cause (i.e., unintentional, self-inflicted, acts of violence) of their injury in which surgical intervention had been done. The age of the included patients ranged from 2 to 60 years, mean age was 27 years, and median was 25 years. Maximum patients were aged between 11 and 30 years and the incidence of such injuries was less in fifth decade onward. There were 60 patients out of whom 47 (78.30%) patients were male and 13 (21.70%) were female.

Clinical presentation In our study, most common clinical presentation at the time of admission was brain matter and cerebrospinal fluid (CSF) leak in 48 (60%) patients, followed by decreased level of consciousness in 40 (66.67%) patients, weakness of extremities in 13 (21.67%) patients. Black eye or orbital injuries were found in 7 (11.67%) patients, and headache and vomiting in 17 (28.33%) patients. Ear or nose bleeding was found in 25 (41.67%) patients and other associated injuries on body were present in 4 (6.67%). Admission GCS was between 3 and 8 in 18 (30%) patients, 9 and 12 in 15 (25%), and 13 and 15 in 27 (45%).

Mode of injury In our study 35(58.3%) patients sustained injury due to fire arm. Majority of them 33/35 (94.4%) had injury as a result of assault whereas 2/35 (5.64%) had accidental injury. Other causes of penetrating head injury were assault by sharp weapon and accidental/machine injury in 10 (16.67%) patients each, whereas plastic pipe (►**Fig. 1**), fire crackers, sports (cycle), suicidal cases, and hit by animal were responsible for injury in one patient each, respectively.

Site of injury Frontal lobe was most commonly involved part in 24 (40%) patients, followed by multiple lobe injury was noted in 16 (26.66%) patients. Parietal lobe was injured in 9 (15%) patients. Four (6.66%) patients had orbitofacial injury whereas 3 (5%) patients had temporal lobe injury. In four patients dural tear was seen, but no injury to brain parenchyma was noted.

Radiological findings On the computed tomographic (CT) scan, contusion was the most common 43(71.66%) finding, followed by presence of foreign bodies (►**Fig. 2**) in brain parenchyma in 24 (40%) patients, external protrusion of brain matter in 20 (33.33%), and bony fragments in the brain parenchyma in 6 (10%). Extradural hematomas were noted in three (5%) patients whereas subdural hematoma was noted in two (3.33%). Pneumocephalus was found in two (3.33%) patients and intracranial hematoma was noted in one (1.67%).

Surgical management In our study, 18 (30%) patients were operated within 24 hours of trauma and 34 (56.67%) were operated between 24 and 72 hours. Eight (13.33%) patients were operated after 72 hours. The delay in surgery was mainly due to delayed arrival to the hospital following injury. Debridement craniectomy and duraplasty were done in 36 (60%) patients and additional contusion removal in 16 (26.67%). Eight (13.33%) patients had brain bulge at operation, and therefore, they required decompressive craniectomy with augmentation duraplasty.

Complications Thirty-nine (65%) patients developed complications in the perioperative period. Wound infection

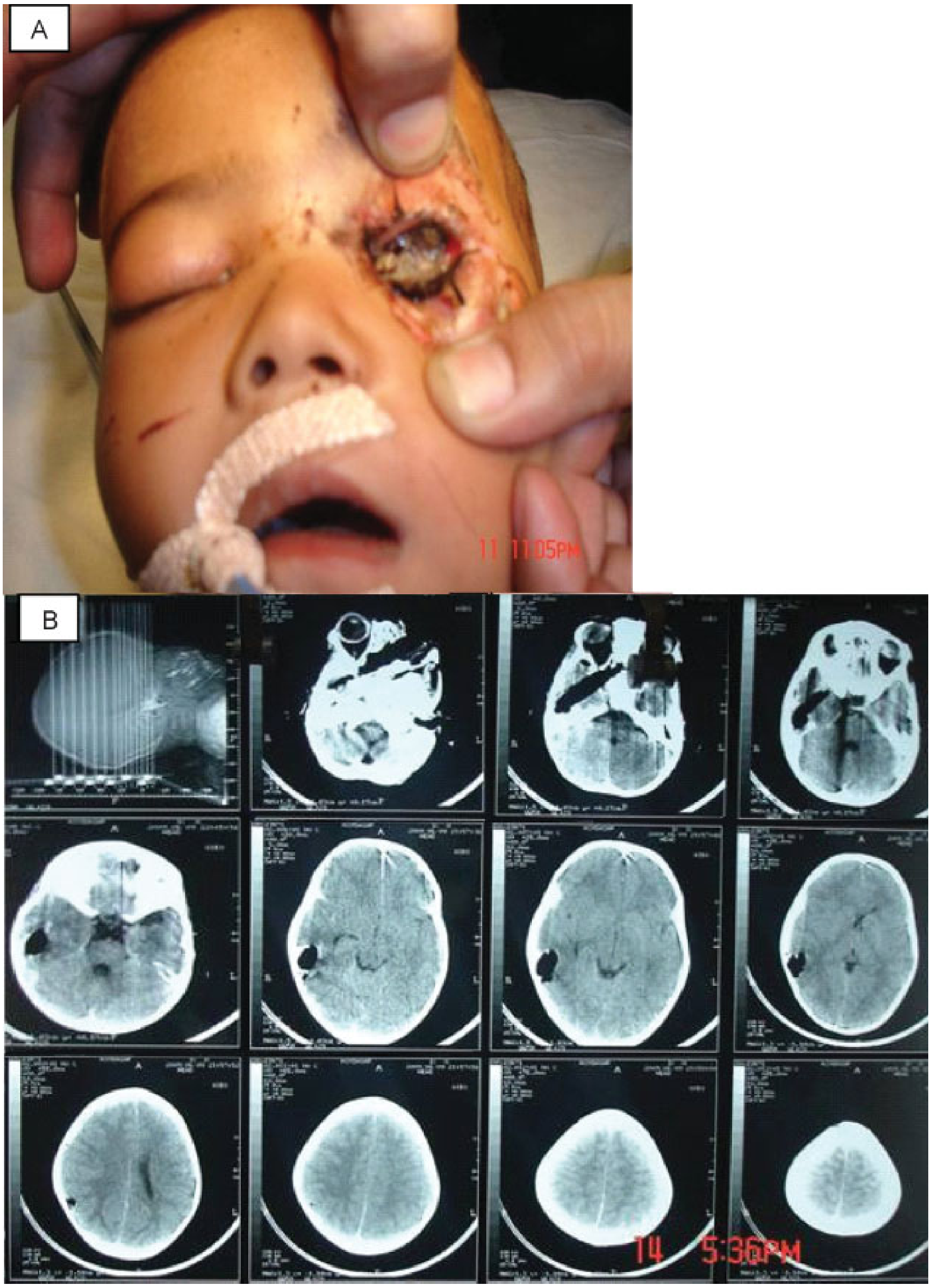

Fig. 1 A 6-year-old boy with accidental injury by wooden stick. (**A**) The patient's photograph with injury through the left eye. (**B**) Noncontrast CT of the head showing foreign body crossing the midline and going to the right temporal lobe.

occurred in 11 (18.33%) patients, which was managed by local debridement of wound and antibiotic according to culture sensitivity report. Hydrocephalus occurred in three (5%) patients requiring ventriculoperitoneal shunting. CSF leak was observed in 3 (5%) patients, which was managed by lumbar drain. One patient each developed meningitis and brain abscess. The patient with brain abscess underwent burr hole aspiration; both, brain abscess and meningitis patients, required prolonged antibiotics. Eight (13.33%) patients developed seizure in perioperative period. None of these patients had seizure before sustaining their trauma. Four patients out of these eight patients who developed seizure expired due to consequence of head injury and respiratory tract infection. Seizure was more common in lower GCS group patients than higher GCS group. In between GCS 3 and 8, there were 18 patients, out of whom 3 patients (16.66%) developed seizure and 2 (66.66%) expired. Patients with GCS 9 to 12 included 15 patients, out of whom only 1 (6.66%) patient developed seizure and expired. In between GCS 13 and 15, there were 27 patients

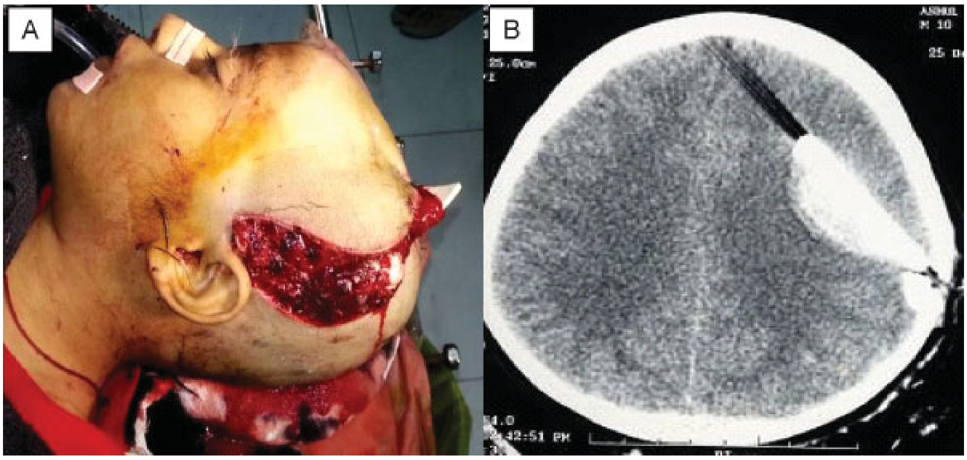

Fig. 2 A 10-year-old boy with accidental injury by plastic pipe. (A) The patient's photograph with plastic pipe inside brain. (B) Noncontrast CT scan head with foreign body in situ.

out of whom 4 (14.8%) patients developed seizure and 1 (25%) expired. All these patients developed seizure in spite of phenytoin loading given for prophylaxis and after ruling out of other risk factor for seizure such as serum electrolyte derangements, blood sugar derangements, and hypoxia. Twelve (20%) patients expired during the hospital stay due to low GCS at admission (4 patients), respiratory tract infection (3 patients), multiple factors—seizures, dyselectrolytemia, septicemia—(5 patients).

Follow-up In our study, duration of hospital stay ranged between 1 and 47 days. Mean duration was 10.6 days and median 10 days. Out of total 60 patients included in the study, 12 (20%) patients expired during the hospital stay. Out of the 48 (80%) survivors, 38 (63.33%) patients were in regular follow-up. The follow-up period ranged from 3 months to 10 years with a mean of 17.1 months and median of 6 months. Ten patients (16.66%) were lost to follow-up.

Outcome Twelve patients expired during the hospital stay (GOS-1). Thirteen patients were discharged in GOS-2, 15 in GOS-3, and 20 in GOS-4, but no patient could achieve GOS-5 till discharge. However, during the follow-up period, 30 (50%) patients had reached GOS of 5 and 5 (8.33%) had GOS of 4. Three patients expired during the follow-up. Cause of death in these patients could not be exactly ascertained.

Discussion

The mortality and morbidity associated with penetrating head injury has decreased with modern neurosurgical care. However, most persons with severe penetrating head injury still die before, during, or shortly after emergency treatment.

Similar to other studies,[7–9] in our study too most of the patients sustaining penetrating injuries were young male and most common modes of such brain injuries were assault by sharp weapon/firearm and accidental/machine injury/road traffic accident (RTA).

Considering the poor outcome of patients with a GCS of 5 or less, some have questioned early aggressive treatment of these patients. There is a controversy concerning aggressive surgical management for patients with a GCS score of 3 to 5. Clark et al reported that there were no survivors among patients treated conservatively with GCS scores of 3, as well as among patients who underwent surgery with a preoperative score of 4 to 5.[10] Grahm et al recommended that patients with a GCS score of 3 to 5 should not be treated with surgery unless there is an operable hematoma.[11] Levy et al reported that patients with a GCS score of 3 to 5 might have a better survival with surgery, but outcomes are generally poor[12] (►**Table 1**).

GCS at admission is an important factor affecting outcome of patients; lower GCS is associated with poor outcome. Five patients out of 18 with GCS group 3 to 8 expired (►**Table 2**). Four patients out of 15 expired in GCS group 9 to 12 and 3 patients out of 27 expired from group having GCS 13 to 15. Therefore the patient considered as having severe head injury and having GCS 3 to 8 should be given a chance of surgery explaining the higher risk of morbidity and mortality associated with it. Overall mortality in our series during perioperative period was 20% (12 patients).

Other prognostic factors are hemodynamic and respiratory status at admission, pupil diameter and its reactivity, and the presence of coagulation abnormalities. Many other radiologic factors including bilateral hemispheric injury, multilobe injury, transventricular trajectory, brainstem injury, intracerebral hematoma or cerebral contusion with an associated mass effect, and

Table 1 Mortality among patients presenting with Glasgow Coma Scale score of 3–8

Series	Mortality (%)	No. of patients	GCS score 3–8 (%)
Liebenberg et al, 2005[13]	69	125	69
Kaufman et al, 1986[14]	66	141	76
Mancuso et al, 1988[15]	40	40	48
Grahm et al, 1990[11]	59	100	64
Current study, 2013	28	60	30

Abbreviation: GCS, Glasgow Coma Scale.

Table 2 GCS on admission and GOS at follow-up

GCS on admission (No. of patients) ($n = 60$)	GOS at discharge (No. of patients) ($n = 60$)					Patients lost to follow-up ($n = 10$)	GOS at follow-up[a] (No. of patients) ($n = 38$)[b]				
	GOS-1	GOS-2	GOS-3	GOS-4	GOS-5		GOS-1	GOS-2	GOS-3	GOS-4	GOS-5
3–8 (18)	(6)	(7)	(2)	(3)	(–)	3	(2)	(–)	(–)	(3)	(4)
9–12 (15)	(4)	(5)	(3)	(3)	(–)	5	(–)	(–)	(–)	(–)	(6)
13–15 (27)	(2)	(1)	(10)	(14)	(–)	2	(1)	(–)	(–)	(2)	(20)

Abbreviations: GCS, Glasgow Coma Scale; GOS, Glasgow Outcome Scale.
[a]Follow-up period was 3 months to 10 years and median follow-up period was 6 months.
[b]Twelve patients expired during the hospital stay, 10 lost to follow-up.

missile and bony fragmentation away from the bullet's path usually indicate an unfavorable outcome and high mortality.

The intracranial bone and metallic fragments that are not removed might be associated with an increasing infection rate. Experimental studies by Pitlyk et al revealed only 4 to 8% incidence of infection with bone fragments when hair or scalp was not accompanied along within the brain matter.[16] The bony fragments have a much greater chance of causing late infection than do metallic fragments. Aarabi et al reported that retained bone fragments led to a greater number of infections, but their correlation was not statistically significant.[17] Brandvold et al reported an infection rate of 11% after a less aggressive approach.[18] There was no correlation between the presence of retained fragments and subsequent development of infection or epilepsy.

Posttraumatic epilepsy is another complication, which reflects the extent of brain damage and is positively correlated with the level of GCS. From combined series, the risk of epilepsy ranges from 1.3 to 24%.[19] In our series, seizure occurred in 8 (13.33%) patients during hospital stay. One patient with GCS 4 developed seizure on 7 postoperative days and could not be controlled by phenytoin, levetiracetam, and lorazepam, and eventually he was given general anesthesia. Other patient with GCS 4, 8, 12, 14 also developed seizure on third, first, fifth, and fourth day, respectively. Seizure was more common in lower GCS group patients than higher GCS group. In between GCS 3 and 8, out of 18 patients 3 (16.66%) patients developed seizure and two (66.66%) expired. Patients in GCS 9 to 12 included 15 patients and of them only 1 (6.66%) patient developed seizure and expired. In between GCS 13 and 15, there were 27 patients out of whom 4 (14.8%) developed seizure and one (25%) expired.

Conclusion

Penetrating brain injuries we observed mostly between 11- and 30-year-old age group and more common in male than female. Most common mode of these injuries was by firearm and most common presentations were brain matter or CSF leak. Frontal lobe was the most commonly injured part of the brain. In our series mortality occurred in 20%. Lower GCS is the most important factor for poor outcome. Higher mortality is seen among patients with seizures compared with other patients with penetrating brain injury.

References

1 Kazim SF, Shamim MS, Tahir MZ, Enam SA, Waheed S. Management of penetrating brain injury. J Emerg Trauma Shock 2011;4:395–402
2 Gururaj G. Road traffic deaths, injuries and disabilities in India: current scenario. Natl Med J India 2008;21(1):14–20
3 Nathoo N, Boodhoo H, Nadvi SS, Naidoo SR, Gouws E. Transcranial brainstem stab injuries: a retrospective analysis of 17 patients. Neurosurgery 2000;47(5):1117–1122, discussion 1123
4 Siccardi D, Cavaliere R, Pau A, Lubinu F, Turtas S, Viale GL. Penetrating craniocerebral missile injuries in civilians: a retrospective analysis of 314 cases. Surg Neurol 1991;35(6):455–460
5 Deng D, Dan G, Tao J, et al. Conventional and contrast-enhanced ultrasound assessment of craniocerebral gunshot wounds. Genet Mol Res 2015;14(2):3345–3354
6 Bhat AR, Wani MA, Kirmani AR, et al. Disaster management of civilian gunshot head wounds in north Indian state. Indian J Neurotrauma 2009;6(1):27–42
7 Kim TW, Lee JK, Moon KS, et al. Penetrating gunshot injuries to the brain. J Trauma 2007;62(6):1446–1451
8 Zafonte RD, Wood DL, Harrison-Felix CL, Valena NV, Black K. Penetrating head injury: a prospective study of outcomes. Neurol Res 2001;23(2–3):219–226
9 Exadaktylos AK, Stettbacher A, Bautz PC, Terries J. The value of protocol-driven CT scanning in stab wounds to the head. Am J Emerg Med 2002;20(4):295–297
10 Clark WC, Muhlbauer MS, Watridge CB, Ray MW. Analysis of 76 civilian craniocerebral gunshot wounds. J Neurosurg 1986;65(1): 9–14
11 Grahm TW, Williams FC Jr, Harrington T, Spetzler RF. Civilian gunshot wounds to the head: a prospective study. Neurosurgery 1990;27(5):696–700, discussion 700
12 Levy ML, Masri LS, Lavine S, Apuzzo ML. Outcome prediction after penetrating craniocerebral injury in a civilian population: aggressive surgical management in patients with admission Glasgow Coma Scale scores of 3, 4, or 5. Neurosurgery 1994; 35(1):77–84, discussion 84–85
13 Liebenberg WA, Demetriades AK, Hankins M, Hardwidge C, Hartzenberg BH. Penetrating civilian craniocerebral Gunshot wounds: A protocol of delayed surgery. Neurosurgery 2005; 57:293–299

14 Kaufman HH, Makela ME, Lee KF, Haid RW Jr, Gildenberg PL. Gunshot wounds to the head: a perspective. Neurosurgery 1986; 18:689–695
15 Mancuso P, Chiaramonte I, Passanisi M, Guarnera F, Augello G, Tropea R. Craniocerebral gunshot wound in civilian. J Neurosurg Sci 1988;32:189–194
16 Pitlyk PJ, Tolchin S, Stewart W. The experimental significance of retained intracranial bone fragments. J Neurosurg 1970;33(1):19–24
17 Aarabi B, Taghipour M, Haghnegahdar A, Farokhi M, Mobley L. Prognostic factors in the occurrence of posttraumatic epilepsy after penetrating head injury suffered during military service. Neurosurg Focus 2000;8(1):e1
18 Brandvold B, Levi L, Feinsod M, George ED. Penetrating craniocerebral injuries in the Israeli involvement in the Lebanese conflict, 1982–1985. Analysis of a less aggressive surgical approach. J Neurosurg 1990;72(1): 15–21
19 Weiss GH, Salazar AM, Vance SC, Grafman JH, Jabbari B. Predicting posttraumatic epilepsy in penetrating head injury. Arch Neurol 1986;43(8):771–773