Nature and management of penetrating craniocerebral missile injuries at Shree Birendra Hospital from November 2001 to November 2002.

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Introduction :

Penetrating craniocerebral injuries are insults in which scalp, cranium and to varying degree dura and brain are traversed by a foreign body. Gunshot wounds are the most common craniocerebral missile injuries in the civilian setting, while shrapnel wounds account for the majority of penetrating craniocerebral injury in military conflicts. These injuries are highly lethal, yet many victims reach the hospital requiring urgent neurosurgical care. Low velocity missile may present a relatively benign clinical picture, high velocity missiles produce large area of cavitary necrosis with extensive skull fracturing and are often incompatible with survival. In the well-executed primary debridement operation and proper wound closure, a large number of patients have their lives saved and more of their neurological function preserved. These patients are treated with neurosurgical interventions and concluded that poor outcome after craniocerebral missile injuries include low post resuscitation Glasgow Coma Scale, presence of hypotesion, an abnormal pupillary response, transventricular injury, mass effect and haemorrhage. Good recovery or moderate disability in 100% of patients with a Glasgow Coma Scale score of 13 to 15 and in 67% of patients with a G.C.S. score of 9 to 12.

Key Words: Craniocerebral missile injury. primary debridment operation. proper wound closure.
Craniocerebral missile injury leading to refractory intracranial hypertension is the main prognostic factor in brain-injured patients, despite progress in the diagnosis and therapy of brain injury.

Background: The insurgents started so called "people's war" seven years ago in Nepal. At the beginning they used only low-velocity firearms and these weapons were not used against army personnel. Suddenly on 23rd November 2001, they attacked army barrack in Dang. This was the first time they have attacked on army barrack and looted high- velocity weapon from Royal Nepal Army. Since then frequent encounters are going on by using high-velocity weapons and different types of bombs. The numbers of victims are increasing. We aimed to show the devastating effects due to craniocerebral missile injuries in army personnel, police and civilians.

Methods: We analysed medical records of 622 casualties admitted at Shree Birendra Hospital from November 2001 to November 2002 and looked the record of 159 deaths who were killed at the site of conflicts or at the hospital immediately after arrival during treatment. During this one year period 34 cases of isolated craniocerebral missile injuries and 43 cases of multi-system injury with involvement of penetrating head injuries were observed. External injury assessment of dead bodies also revealed the higher percentage of killed army personnel had craniocerebral penetrating missile injuries. Seventy-seven medical records were collected from regular army, ex-army, Army family, Janapath police, Shashastra police, civil and insurgents.

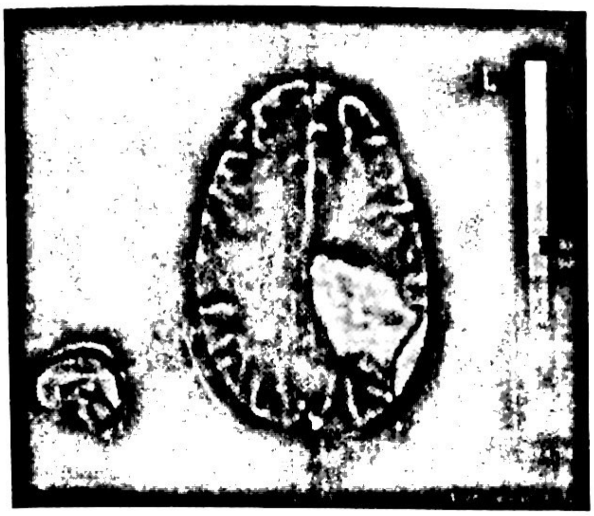
Clinical standard management: Most of the victims were evacuated form the site of conflict to Shree Birendra Hospital by helicopter as soon as possible. Once in the hospital, the patients were haemodynamically stabilized after securing airways and breathing, a careful examination of the head and neck was performed and looked for entry and exit wounds. A neurological assessment was carried out and level of consciousness was recorded by using Glasgow Coma Scale. All stable patients were sent for x-ray skull to see metallic fragments and skull fractures. Any patient demonstrating progressive neurological deterioration, pupillary dilatation or hemiparesis received a bolus of Mannitol 20% 1 gm/kg, before sending them to M.R.I. brain. Patients who have metallic fragments in their skull x-ray were send for C.T. scan of head to other hospital. Broad spectrum antibiotics, tetanus toxoid and loading dose of Phenytoin were given to each patient but corticosteroid was not used. In haemodynamically stable patients with a Glasgow Coma Scale of 3 to 5 who have no significant haematoma in M.R.I. head, a non-operative approach of management was started by elevating the head to a maximum of 30 degree, sedation and analgesic medication and, if needed muscle relaxant, artificial ventilation and osmotherapy. If, however, a haematoma with mass effect was discovered on M.R.I. brain emergency craniotomy, debridement and clot evacuation was performed.

Hemispheric bullet injury with involvement of deep structure.

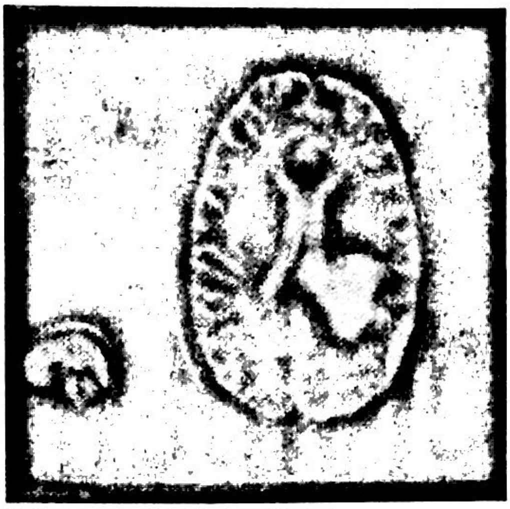
Transventricular missile injury.

Bihemispheric missile injury.

Missile injury of the frontal lobe.



Missile injury of the left hemisphere.



Craniocerebral missile injury with involvement of deep structure and lateral ventricle.

Surgical technique: Haemodynamically stable patients with craniocerebral missile injuries were taken to operating theatre as earlier as possible. The time frame was very wide from 2 hours to 36 hours after gunshot injury. We prepared the entire scalp and draped it in such a way that the entry and exit wounds were accessible without difficulties. Betadine solution was used for skin antisepsis. In the presence of entry and exit wounds, initially we debrided the entry wound then only moved to exit wound for debridement. In majorities of patients the scalp wound was extended and craniectomy was performed but in those patients who were harboring a large intracranial haematomas underwent craniotomy. During surgery dural opening was enlarged, intracranial haematoma was evacuated, necrotic and contused brain was removed and only accessible bone and metal fragments were removed. The suction and saline irrigation were used for removal of haematomas. Necrotic and contused brain removal was only limited in eloquent areas and in deep structures. In few occasions an entire temporal lobe was unsalvageable and in such situations partial lobectomy was performed. The involvement of frontal lobe also treated with generous removal of brain tissue. In all situations, wound was irrigated with normal saline copiously after achieving haemostasis. In all cases water tight dural closure was performed by using pericranium. In case of craniotomy the bone flap was placed back and secured with no.1 Proline suture. Precise apposition of the scalp wound edges was performed by using rotation flaps. Subgaleal suction drain was used selectively. The suture material used for dural closure was 4/0 Vicryl, for galea aponeurotica 2/0 Vicryl and 2/0 Proline for skin closure. During surgery for haemostatic purpose bipolar diathermy was used and in some occasions gelfoam or surgicel were used but at the end of surgery these haemostatic materials were removed. Re-exploration was performed on one patient who underwent frontal lobectomy and he made good recovery with minimal deficit of cognitive functions. Post operative care of these patients with craniocerebral missile injuries was same as that for patients with other forms of severe head injury.

Data collection: The following patient data were prospectively collected in standard protocol: age of the patient, rank, personal number, unit, date and time of injury, means of evacuation, time of arrival in the hospital, mechanism of injury, neurological status by using Glasgow Coma Scale, pupillary response on the day of injury and on the first post operative day, surgical procedures, post operative complications, duration of post operative coma and outcome. All survival patients are on follow up review except civilian ones who have no outdoor treatment facility in the Birendra Hospital.

Result: A large number of patients who sustained craniocerebral bullet injury have died, most within hours or at least one day which was distinctly noted while examining the type of injury in dead bodies brought to hospital after each conflict. Most of dead bodies have gunshot wounds to the head. Most of patients who arrived to hospital with through and through transventricular injuries, bihemispheric injuries with Glasgow Coma Scale 3 to 5 also died within seven days of injury. Patients arriving to hospital in time within 6 to 12 hours of injury with tangential missile wounds made good recovery with minimal disability. These patients had good Glasgow Coma Scale of 11 to 14. Victims of rubber bullet injury of the brain also made good recovery. Patients with shrapnel injury to head also made good recovery. In all series no patient was seen with posterior fossa injury. The main predictors of poor outcome after craniocerebral missile injury were low Glasgow Coma Scale of 3 to 5, hypotension, abnormal pupillary reflexes and refractory intracranial hypertension. A few patients made surprisingly good recovery in term of mentation, resolution of focal findings and restoration of their duties despite bihemispheric injury with low Glasgow Coma Scale on admission.

Discussions: Gunshot wounds of the head are on the increase. The easy availability of handguns, revolvers, shotguns, and rifles and the continued and increasing arm struggle in various places in the world demand a renewed and serious interest in and a better understanding of both the ballistic characteristic of missile and the surgical pathology of missile wounds. Historically speaking, major philosophical changes in the treatment of penetrating head injury have followed the wake of major armed conflicts. Each war has had different lessons to teach. World War I, for example, proved the efficacy of vigorous surgical intervention. The Spanish Civil war demonstrated that blast effect after aerial bombardment. During World War II, the importance of initial dural repair and antibiotics medication. The Korean War confirmed the effectiveness of early evacuation and initial definitive operation in improving survival and reducing infection. In the 1970s the civil disturbances in Belfast took place so close to the neurosurgical center that the natural history of penetrating injury could be studied virtually from the moment of injury. Following the conflict in Vietnam, the long-term outcome of penetrating injury was studied through the Vietnam Head Injury Study. Most recently, in the course of the Arab-Israeli conflict in the Middle East, the usefulness of sectional imaging in combat neurosurgery was demonstrated. The availability of virtually immediate computed tomography proved essential for localizing fragments and visualizing the extent of injury. More importantly, however, the availability of C.T. led to the development of a more conservative surgical technique with no demonstrable increase in complications.

Penetrating head injuries are insults in which scalp, cranium and to varying degree, dura and brain are traversed by foreign body. They can be divided into two basic categories: missile injuries and stab wounds. Gunshot wounds are the most common cranial missile injury in the civilian setting, while shrapnel wounds account for the majority of penetrating head injury in the military conflicts. These injuries are extremely common, they are highly lethal, yet many victims reach the hospital requiring urgent neurosurgical care.

Missile ballistic and pathophysiology: The extent of injury caused by a missile is closely related to the kinetic energy it contains on impact with its target. The energy is defined by the formula:

$$KE=1/2M(V_1^2-V_2^2)$$

Where M is the mass of the missile and V its velocity. Because the energy of the projectile is related to the square of the velocity, this factor is relatively more important than mass in determining tissue destruction. The energy released into the target is dependent on the impact energy and the residual energy of the projectile. A bullet that enters the calvarium and does not exit will impart all its energy into the head. Most handguns and revolvers use heavy bullets weighing about 0.5 oz and have muzzle velocity ranging from 550 to 900 ft/sec. These are referred to as low velocity missiles. In contrast most of today's rifle use very light bullets less than 10 grams and have muzzle velocity with a range 2300 to 6000 ft/sec. These are referred to as high-velocity missile. Fragments of high-explosive devices are of various shapes and sizes and can weigh as much as 100 grams. These are high velocity in the beginning but become low-velocity missiles at the distance as near as 10 meters.

The pathophysiology of cranial missile injury is based on three primary events occurring at impact. Local parenchymal destruction occurs along the bullet tracks. A temporary cavity forms parallel to the primary track that may be much larger than the missile diameter and collapses within milliseconds. A shock wave, occurring immediately after impact, is then transmitted throughout the intracranial cavity. If the bullet has insufficient energy to exit the skull, it may ricochet off the inner table opposite the entry site, or off the dural barrier such as the falx or tentorium, creating a second and occasionally a third track. The course of such a rebounding bullet is highly variable. If vital brain stem structures are transgressed by the projectile, the victim generally dies at that instant. Even without anatomical disruption of vital centers, the shock wave alone may be severe enough to produce transient or permanent medullary failure with cardio-pulmonary arrest. If deep brain structures are not primarily injured by the missile itself, from the effect of temporary cavitation or by blast effect, several secondary phenomenon can also occur that further complicate the overall brain injury and may ultimately result in the patient's death. The pressure wave associated with a bullet entering the calvarium can cause distant cerebral injuries, including cerebral contusion and uncal and tonsillar herniation. The source of raised intracranial pressure after a cranial gunshot wound in the absence of haematoma formation is not entirely clear.

Additional insult after the primary missile injury may include laceration of major cerebral vessels, resulting in haematoma formation or trarumatic aneurysm development. Local parenchymal damage along the bullet path and within the area of temporary cavitation causes release of tissue thromboplastin and plasminogen and may result in a consumptive coagulopathy. Multiple in-driven bone fragments, usually traveling less than a third of the distance of the primary missile track can create additional swaths of brain destruction. Finally scalp, hair, clothing and other foreign bodies may be pullet intracranially by the bullet, providing multiple nidi for an infection.

Tangential missile injuries result when a bullet or piece of shrapnel strikes the skull at a sufficiently oblique angle to be deflected away from the cranium. There is no intracranial penetration by the missile itself, but bone may in-driven a considerable distance, causing dural and parenchyma lacerations as well as haematoma formation. Most of spent bullet injuries occur during the vertical descent of the bullet. Explosive bullets that detonate on or shortly after impact are formally prohibited by the rules of war, but they have been available on the civilian market and are used by terrorist groups.

Triage and transportation of the injured: If at all possible, triage should be deferred until after initial pre-hospital and emergency stabilization has been accomplished. Stabilization prior to neurosurgical evaluation allows a more accurate diagnosis. If a patient cannot be stabilized systemically, there is not much point to contemplating neurosurgical intervention.

Investigation: After a careful neurological evaluation, base line laboratory investigations were requested and plain roentgenograms of the skull should be obtained to determine the entry and exit points of the missile, the extent of bony fracture, the volume of any bone that has been driven intracranially, the presence of any metallic fragments, the trajectory of the bullet, which may suggest the areas of penetration and bullet fragmentation and the extent of radial fragment scatter such as occurs with soft-point and copper-jacketed military bullets to predict the expected neurological deficit. Computed tomography of the brain should be obtained in every case when feasible. M.R.I. has little role to play in missile injury.

Management: The military approach to penetrating missile injuries does not differ significantly from the approach taken in civilian practice. The goals of surgical interventions are quite specific: to remove space occupying lesions, to prevent infection, to produce haemostasis and to repair and restore anatomic integrity to the injured structures. As a general rule, vigorous operative debridement of the missile track is recommended to prevent abscess formation. The choice of scalp incision and the use of a craniotomy or a craniectomy are dictated by the nature of the wound. The dura should be closed in water tight fashion, with a graft when necessary to prevent tension. Cranioplasty may be undertaken at the time of initial explorations with great caution. A meticulous reconstruction and closure of the scalp is effected. The use of drains does not seem to affect the development of wound infection. Antibiotics should be given prophylactic ally as soon a feasible. Anticonvulsant prophylaxis is routinely used. There is no evidence, at this time, to support the use of steroids in head injured patients. The role of intracranial pressure monitoring has yet to be fully defined. Angiography is performed selectively.

Overall outcome: If we review the recent series, the prognosis of craniocerebral bullet injuries depends on post-resuscitation Glasgow Coma Scale, presence of hypotension, the missile trajectory, the intracranial or subarachnoid haemorrhage, intracranial hypertension and age of the patients. For analysis the Italian series by Siccardi and associates included victims who died on the scene or while en route to the hospital and found 73% died on the scene, another 12% died within 3 hours of injury, and 7% died beyond this time; total mortality was 92%. Aarabi's report on Iran-Iraq war focused on the postoperative course in 435 patients, while Branvold and co-workers studied 113 men form Israeli-Lebanese conflict. In the study by Aarabi, wounds were penetrating in 61%, tangential in 29.5% and perforating in 9.5%, with perforating injuries causing almost twice the mortality of penetrating or tangential wounds. Overall, 79% of patients had a good outcome and 16% of patients died at 6 months or more of follow-up. In the report by Branvold and co-workers, median time from injury to arrival at the hospital was only 2 hours. 48% of patients were admitted with a G.C.S. of 10 or less and 26% had either a decerebrate or flaccid motor response. Multi-system injury occurred in 40% of patients. 75% of patients underwent definitive operative debridement and 9% were too neurologically devastated or haemodynamically unstable to undergo surgery. At discharge good outcome was seen in 62% of patients and mortality was 26%. In our series the mortality was 16% but the number of victims is less than 100 therefore given statistic value may not be relevant.

Conclusion: Craniocerebral missile injuries are serious injuries with high mortality rate. These injuries can present with different clinical pictures, which are largely based on the different types of damage inflicted on the brain and the area involved. Low-velocity missile may present a relatively benign clinical picture while the high- velocity missiles produce large areas of cavitary necrosis with extensive skull fracturing and are often incompatible with survival. There are no truly silent areas in the brain therefore every approach to the treatment of penetrating head injuries must emphasize the preservation of the brain tissue. Well executed primary debridement operation and proper wound closure will save more lives and preserve neurological functions.

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