Missile Injuries of Brain - an Experience in Northern Sector

Col Prakash Singh*, Brig GS Misra, ^{VSM} +, Col Amarjit Singh#, Lt Col MGK Murthy (Retd)**

Abstract

During a period of one year, from Jan 99 to Dec 99, 60 cases of missile injuries were treated at our centre. 59 were males and one was a female and their average age was 25 years. 43 patients had suffered splinter injuries, 12 had gunshot wounds and 5 had suffered injuries by improvised explosive devices. Glasgow coma scale was < 5 in 8 patients, 5-8 in 14, 8-12 in 30 and 13-15 in 8 patients. Extensive comminution of skull bones was found in 10 patients. 35 patients had more or less clear penetration of the skull and the rest had orbito-cranial or facio-cranial wounds. CT scan revealed small haemorrhagic contusion with in-driven bones without mass effect in 15, contusion with mass effect in 36 cases, cortical contusions without in driven bones (tangential injuries) in 3, distant intracranial contusions in 4, intraventricular haemorrhages in 5, multilobar injuries in 14, and unilobar injury in 40. 52 patients were operated upon at our centre of which 30 were operated within 24 hours, 10 between 24 to 48 hours, 12 between 48-72 hours. Six patients were treated conservatively and 2 required only simple closure of scalp wound. Craniectomy was done in 10 and craniotomy in 42 patients. Two patients developed wound sepsis, one each developed aspiration pneumonia, septicemia, deep vein thrombosis and post-traumatic hydrocephalus. On follow up at 6 months, outcome as per Glasgow outcome scale was as follows : good outcome - 42, moderate disability in 7, severe disability in 6 and death in 5 patients. Retained bone fragments were found in 40% on follow up CT scan but none had brain abscess.

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Key Words : Brain; Craniotomy; Favourable outcome; Less aggressive surgery; Missile injury

Introduction

Since the invention of gunpowder and firearms, missile injuries of brain have become an unavoidable consequence of military conflicts. Literature is replete with efforts of neurosurgeons for the care of these injuries. Harvey Cushing was first to advocate early and definitive debridement of necrotic tissue, removal of all indriven debris and meticulous dural and scalp closure. He could reduce the operative mortality from 54% to 28% [1]. During the early part of World War II and Korean War, brain abscesses were routinely found in association with retained bone fragments [2,3,4]. Because of this experience, aggressive initial debridement of missile tract was adopted during Vietnam War and as a result, infection rate declined from 53% to 15% and surgical mortality was also markedly reduced [5]. Despite these results, the issue of causal relation of retained bone fragments and development of brain abscess remained speculative as there was evidence to the contrary as well. Maltby [6] found only 3 cases of retained bone fragment in a group of 17 cases of brain abscess during World War II. Experimental studies by Pitlyk et al [7] also noted only 4-8% incidence with sterile and contaminated bone fragments if not combined with hair or scalp. Phase I and II Vietnam head injury study did not find any evidence to incriminate retained bone fragment in the development of brain abscess [8,9].

With the availability of CT scan, rapid evacuation of casualties, better follow up, neurosurgical care, a less aggressive intracranial debridement, with emphasis to preserve the brain tissue, was adopted during Israeli-Lebanese and Croatian conflicts and outcome was better [10,11]. Though great attention has been given to brain injury, dural repair and scalp closure, the treatment of fractured bone has been neglected. Bone was discarded either after block resection [1] or after craniectomy as advocated by Matson [12] and this has been the general practice till recent past [10], though early attempts to preserve the bone were also made [2,13]. We are presenting our experience of 60 cases of missile injuries treated with less aggressive debridement of missile tract, preferring craniotomy to craniectomy whenever feasible and in case of craniectomy, bone fragments were replaced if condition of brain and wound permitted, thus avoiding future cranioplasty.

Material and Methods

During a period of one year from Jan 99 to Dec 99, 60 cases of missile injuries of brain were treated at our hospital. 22 of these pertained to Kargil war and 38 to other militancy related activities in the state of Jammu and Kashmir (J&K). 30 cases were directly evacuated to our hospital and 30 cases came after initial treatment at other forward hospitals, 8 of these were operated and the other 22 were not operated but administered antibiotics and applied sterile dressings.

*Senior Advisor (Surgery & Neurosurgery), Army Hospital (R&R) Delhi Cantt - 110 010, *Dy DGAFMS (P&T), Ministry of Defence, 'M' Block, New Delhi-110 010, #Senior Advisor (Anaesthesiology), 158 Base Hospital, C/o 99 APO, **Classified Specialist (Radiology), Command Hospital (Northern Command), C/o 56 APO.

Average time of arrival at our hospital was 30 hours but varied from 4 to 120 hours.

All patients were assessed for patency of airway, breathing pattern and circulatory status. Neurological assessment was done by Glasgow coma scale (GCS) score, pupillary size and reaction, other brain stem reflexes and limb movements. Clinical evaluation was completed by local examination of missile wound and examination of other systems. Resuscitative measures were initiated if patient required respiratory support or was haemodynamically unstable. Patients having GCS score of less than 8 were intubated and ventilated. X-ray skull was done in all cases and CT scan was done in 54 cases. MRI study was done in 5 cases. Wound cultures were done in 20 cases. All patients were put on sodium penicillin, gentamicin and cefotaxime. Metronidazole was added if the missile had traversed any air sinus. Parenteral phenytoin and ranitidine were also started. Mannitol and frusemide were given if features of raised intra cranial pressure were seen on imaging studies.

52 patients were operated at our centre; of which 46 were initial debridement and 6 were re-operations after initial debridement at forward hospitals. Operative procedure comprised debridement of the scalp wound and then "Z" or "S" extension of this wound or raising of scalp flap depending upon requirement of skull exposure or closure of scalp wound. A craniotomy was performed, centered over the skull penetrance. The margins of missile tract in the bone were minimally (0.5 to 1 cm) debrided. The size of craniotomy was dictated by underlying brain damage. A craniectomy was performed if there was extensive comminution of the skull bone or wound was badly contaminated. The dural wound was completely exposed and its shredded margins trimmed and then dural opening enlarged with further extensions as required. Superficial necrotic brain tissue was removed with suction and missile tract was washed with saline using a catheter. No suction was introduced into the missile tract. Missile or bone fragments that presented themselves into the wound were picked up with forceps and removed. No extra manoeuvre was made to remove all the missile and bone fragments seen on imaging studies. Haemostasis was achieved with bipolar coagulation and no gel, foam or surgical gel was used for achieving haemostasis except for venous sinus injuries. Missile tract was finally washed with hydrogen peroxide and saline. Dural defect was repaired with a pericranial or temporal fascia to achieve a watertight closure. Bone flap was replaced and fixed with vicryl sutures. In case of craniectomy large bone fragments were washed with saline and replaced back. The wound was now irrigated with 1% povidone iodine. Scalp was closed in double or single layer with a subgaleal drain. Post operatively antibiotics were continued during peri-operative period for 2 weeks and anti epileptics continued even thereafter. Cerebral decongestants (mannitol, frusemide and glycerol) were continued as dictated by the extent of injury and if required, postoperative ventilation was instituted. Intra cranial pressure was monitored in 10 patients for 72 hours who had poor GCS score and extensive brain injury. All the 55 surviving patients

were followed up to 6 months after injury. Complete neurological assessment, X-ray skull and CT scans of the head were done in all cases.

Results

A total of 60 patients with missile injuries of the head were admitted at Command Hospital (Northern Command) C/o 56 APO. Their age varied from 19 to 40 years with a mean age of 25 years. 59 were male and one was female. 43 injuries were caused by shrapnel of shells, 12 were gunshot wounds and 5 by improvised explosive devices (IEDs). Regional distribution is given in Table 1, showing parietal being the most common followed by the orbito cranial/facio-cranial penetration. Punctate wounds were found in 10 cases and rest 50 had significant scalp laceration and brain matter was oozing out in 40 of these. GCS score was 3-5 in 8, 5 - 8 in 14, 8-12 in 30 and 13 - 15 in 8 cases. Associated eye injuries were found in 7, facial in 8, limb in 10, chest in 3 and tracheal injuries in one patient. X-ray skull was done in all cases which revealed skull penetrance without significant comminution in 35 (Fig 1) and extensive comminution of bone in 10 cases (Fig 2). Missile fragments were seen in 48 cases. CT scan of the head was done in 54 cases and was very helpful in assessing the extent of brain damage and location of bone fragments and missiles. Details of CT scan findings are given in Table 2. In 15 patients CT scan revealed small haemorrhagic contusion with indriven bones without significant mass effect (Fig 3), contusion with mass effect was found in 36 cases (Fig 4), cortical contusion without indriven bones in 3 (Fig 5), distant intracranial contusion in 4 (Fig 6), intraventricular haemorrhage in 5 (Fig 7) and multilobar injury in 14 cases (Fig 8). Missiles were found at the distal end of injury tract and bones at the proximal. MRI study was done in 5 cases in whom the missile had passed through the skull and X-ray did not show any missile in head or any other part of the body. Though missile tract and brain contusion could be appreciated, bone fragments could not be appreciated on MRI scan, however brain stem contusion away from missile tract was seen in one case (Fig 9).

Table 1

Regional distribution of injuries

Site of injury	No	Percentage
Frontal	11	18.3%
Parietal	20	33.3%
Temporal	10	16.7%
Occipital	04	6.7%
Orbitocranial/Faciocranial	15	25%
Total	60	100%

Acute surgeries were performed in 52 patients of whom 6 were re-operations for inadequate initial surgery done at forward hospitals. Time interval between time of injury and time of surgery varied from 6 to 72 hours with an average of 36 hours, however antibiotics were started within 6 hours of injury in all patients. 30 cases were operated within 24 hours of injury, 10 between 24 to 48 hours and 12 were operated

Table 2

CT scan findings

Description	No	Percentage
Small focal haemorrhagic contusion with driven bone without significant mass effect (Fig. 3)	15	28%
Haemorrhagic contusion with mass effect (Fig. 4)	36	67%
Tangential wounds with cortical contusions (Fig. 5)	03	5.5%
Distant haematomas (Fig. 6)	04	7.5%
Intraventricular bleed (Fig. 7)	05	9.3%
Multilobar injuries (Fig. 9)	14	26%
Unilobar injuries (Fig. 7)	40	74%

Table 3

Predictors of outcome

	Total No	Death	Severe disability	Moderate disability	Good outcome
GCS					
< 5	08	03	03	02	0
5-8	14	02	03	04	05
9-12	30	-	-	01	29
13-15	08	-	-	-	08
Unilobar injury	40	-	-	04	36
Multilobar injury	19	05	06	03	05
Intraventricular-haemorrhage	05	02	01	01	01
Venous sinus injury	03	01	-	-	02

Cause of severe disability : Cognitive function impairment - 02, Aphasia - 01, Hemiplegia - 04; Cause of moderate disability : Hemiparesis - 02, Dysphasia - 01, Hemianopia - 04

between 48 to 72 hours after injury. This delay was due to delay in evacuation from forward hospitals. In 3 cases of punctate wounds and 3 cases of orbitocranial injuries, no surgery was done as they had minimal intracranial injury and had reached at our centre after 96 hours of injury. Two patients were treated with simple wound closure at forward hospitals within 24 hours of injury.

For exposure of skull, scalp flap was raised in 20 cases and in 32 cases missile wound was extended with 'Z' or 'S' extension. Craniotomy was done in 42 of which 18 were frontal, 19 parietal and 3 temporal and 2 occipital. Craniectomy was done in 10 cases and in 7 of these, bone fragments were replaced after washing with hydrogen peroxide and saline. In remaining three, the bone was discarded due to unhealthy looking wound in two and swollen brain in one case. All but two wounds healed primarily, two patients developed mild scalp wound sepsis and culture grew *Staphylococcus aureus*, which responded to antibiotics. Aspiration pneumonia, septicemia, lower limb deep vein thrombosis and post traumatic hydrocephalus developed in one each. We had no case of cerebro spinal fluid (CSF) leak in operated cases. 2 of 3 cases of orbito-cranial injuries treated conservatively developed CSF orbitorrhoea and were subsequently operated. 5 patients in our series died in post operative period within a week of surgery. Three of these had GCS score of <5 and two

Fig. 1 : Skull radiograph showing round penetration in the skull without comminuted fractures

Fig. 2 : Skull radiograph showing a break in the skull with extensive comminution of adjacent bone

<8. Other factors contributing to mortality in these cases are depicted in Table 3.

Our follow up varied from 3 to 9 months with an average of 6 months. Outcome as per GCS was good in 42, moderate disability in 7, severe disability in 6 and death in 5 cases. The disabling factors were aphasia in one, hemiplegia in 4 and significant cognitive function impairment in 2 cases. We had no case of brain abscess formation or osteomyelitis of craniotomy bone flap or replaced bone fragments. However, 22 (40%) of our cases revealed retained bone fragments and 18 (33%) missile fragments (Fig 10) on follow up CT scans.

Discussion

Till the availability of CT scan, the dictum in the

Fig. 3 : CT scan showing small haemorrhagic contusion of occipital lobe without significant mass effect. Bone fragments also seen in proximal part and splinter at far end of injury tract.

Fig. 4 : CT scan showing contusion of left temporal lobe with significant mass effect. Adjacent CT scan 3 months later shows atrophy and gliosis of left temporal lobe

management of missile injuries of head had been to aggressively debride the missile tract, with an effort to locate and remove all the indriven bone and metal fragments and even to the extent that re-operation was strongly recommended if post operative radiographs showed residual bone fragments [3,5]. During the review of Phase I and Phase II Vietnam head injury study, it was found that only small percentage of brain abscesses were associated with bone fragments and despite

Fig.5 : CT scan shows left cortical contusion in a tangential wound. There was no breach in the bone

aggressive debridement 23% cases were found to have residual bone fragments on CT scan study. Therefore, re-operations on asymptomatic patients are not warranted [8,9,14]. With the availability of CT scan, less aggressive surgical approach has been used successfully in civilian and military missile injuries of the brain by many neurosurgeons [10,11,15]. CT scan is essential for such an approach to obviate the need for extensive exploration and to limit the surgery for decontamination of wound, haemostasis and to reduce intracranial pressure. Our results confirm that less aggressive approach gives equally good results in these cases.

Though surgical mortality rate reported by aggressive debridement group was lower [16] than in the less aggressive group [10,11], the studies are not matched and higher mortality in the less aggressive groups has been attributed to more serious patients in these series. Our mortality rate of 8.5%, matches favourably with 11% surgical mortality reported in more aggressive debridement group from western literature [16] and much higher mortality (36.4%) from our country [17], despite the fact that we even operated patients with GCS score of <5. The point whether one should operate on a patient with GCS of less than 5 or not, remains debatable. Though Graham et al [18] advocate no surgery

Figs. 6 a and b : a) CT scan shows missile contusion in the left frontal lobe and distant contusion in the temporal lobe; b) CT scan showing large right frontal EDH with missile just embedded in the skull.

for this group of patients, if they had no intracranial mass lesion, in our series we found intracranial mass lesion in all patients in this group. 5 out of 8 patients with GCS of <5 in our series survived, 3 with severe disability and 2 with moderate disability and therefore to withhold surgery in this group of patients may be rather difficult; even though the result of surgery may be poor. One of our patients in whom the missile had passed through the skull and therefore a MRI scan was performed, revealed evidence of distant effects of missile

Fig. 7 : CT scan showing intraventricular haemorrhage with large frontal ICH.

injury on the brain stem along with large contusion of temporal lobe (Fig 9); he died despite surgery. Though no conclusion can be drawn from this single case, however when brain stem injury is demonstrable on imaging study, there is no benefit in operating such a patient even in the presence of mass lesion.

GCS score has been found to be main determinant of outcome in our series (Table 3). A lower GCS score predicts poor outcome and higher one better outcome [10,15,17,18]. Other factors, which are associated with poor outcome are multilobar injuries, intraventricular haemorrhage and dominant hemispheric injuries as evident from Table 2. Similar observations have been made in earlier studies [10,11,15,17,18].

One of the main concerns of less aggressive surgery has been fear of development of brain abscess [3,5,8]. However, studies from Vietnam War, when more aggressive surgical approach was adopted, reported an incidence of 8.4% and in less aggressive approach an incidence of 1.8 to 10% [10,11]. Various factors associated with the development of intracranial sepsis in missile injuries of the brain are CSF leaks, skull base injuries, extensive brain injury, prolonged coma, transportation time of >48 hours and retained intracranial

Fig. 8 : CT scan showing bifrontal haemorrhagic contusions

missiles and bone fragments [3,19,20]. In the absence of other factors, brain abscesses do not occur in patients with retained bone or missile fragments [8,9]. In our series, we had no case of brain abscess, this is important when we compare with 9% (4/47) septic intracranial complications reported in the missile injuries of the head during 1971 Indo-Pak War [21]. Though our period of follow up is comparatively shorter than other series [8,10,11], since majority (90%) of brain abscesses develop within 6 weeks of injury [22], the chances of late abscess formation will be remote. The main factor, which may relate to such a result in our series, is that we had no CSF leakage from operative wounds and majority (40) of our cases were operated within 48 hours and may be, early institution of effective antibiotics against intra cranial infections at forward hospitals might have contributed to some extent towards this result. Various regimes of antibiotics from only methicillin to combination of penicillin, chloramphenicol, aminoglycosides and metronidazole have been used with a reported intracranial infection incidence of 5-10% [11,23]. We have used a combination of penicillin, aminoglycoside and 3rd generation cephalosporin, metronidazole was added if an air sinus was transgressed and had no peri-operative intracranial sepsis. We did

Fig. 9 : MRI showing large left temporal contusion with mass effect but there is contusion of brain stem though brain stem was far away from missile tract. Missile had entered from left cheek and exited from left temporal region

have 2 cases of wound sepsis, which could be managed without surgery. During the 6 months review, CT scan did not show any evidence of intracranial sepsis. Whether early institution of antibiotics at forward hospitals or use of our combination of antibiotics has helped toward this result is difficult to say. However, it needs to be made clear that antibiotics are no substitute for early surgical debridement. 40% of our cases had retained bone and 33% missile fragments and none were associated with brain abscess, thereby supporting earlier observations that retained bone and missile fragments are usually not the cause for development of brain abscesses [8,9,10,11,13].

Retained bone fragments are not known for exerting any deleterious effect on the prevalence of seizure, however retained metal fragments especially those of copper have been mentioned as a factor for epileptogenesis [24]. But incidence of 22% in 6 year follow up in less aggressive debridement group [10] and 29% in 2 year follow up in aggressive debridement group [25] would allay any such fear. A relatively low incidence in less aggressive surgery group has been attributed to

Fig. 10 : a) CT scan showing retained bone fragments; b) CT scan showing retained splinter

less cortical volume loss. Our follow up has been too short to comment on this aspect.

The indications for craniectomy and craniotomy have really not been outlined. Harvey Cushing was first to practice and advocate en-block resection of cranial bone in missile injuries of the brain during World War I and centrifugal craniectomy was routine procedure during World War II and thereafter [10,12], even though there

have been attempts to preserve the bone as well. Ascroft could preserve the vascularised bone fragments [2] and Hugh Cairns advocated craniotomy for small clean wound [3]. The criteria for selection of craniotomy and craniectomy was laid down by Rich et al [26] i.e. if exposure required is large, the surgery is done shortly after injury, there is no gross contamination of wound and no significant comminution of bone. We have only considered gross contamination of wound, extensive comminution of bone and rarely brain swelling and could perform craniotomy in 42 cases, even when surgery was done upto 72 hours after injury and had no post operative osteomyelitis or wound sepsis. Whereas 2 patients in craniectomy group developed wound sepsis none developed osteomyelitis. We presume that if wound is not badly contaminated, these skulls can be better reconstructed with mini or microplates if available and thus subsequent cranioplasties can be avoided.

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