CLINICAL STUDIES / ETUDE CLINIQUES

CRANIOCEREBRAL MISSILE INJURIES IN CIVILIAN KASHMIR – INDIA

PLAIES CRANIO-CEREBRALES PAR BALLES DURANT LA GUERRE CIVILE AU CACHEMIRE

RASHID Bhat Abdul [1]
WANI Muhammed Afzal [1]
KIRMANI A.R. [1]
RAINA T.H. [1]
ALAM Shafiq [1]

1. Department of Neurosurgery, SKIMS Srinagar, Kashmir-India

E-Mail Contact - RASHID Bhat Abdul : huwa9adam (at) gmail (dot) com

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ABSTRACT

Background

The missile injuries of the cranium and brain in the modern era have shifted from soldiers to the civilians and from the battle grounds to the populated zones due to increase in the terrorist and military strikes. The management of the victims depends on the resuscitation at the site of injury and the distance and transportation to the tertiary care centre. This article presents the details of the missile injuries to the brain, the third-world problems and the management.

Material and methods

A retrospective analysis of 3794 craniocerebral missile injuries, managed by the Department of Neurosurgery at Sher-I-Kashmir Institute of Medical Sciences (SKIMS) Kashmir, India, over a period of more than 21 years from September 1988 to September 2009. Patients were triaged in emergency CT-room, resuscitated and operated. Statistical software programme SPSS 11.5 was used to derive the numerical significance.

Results

Revealed an overall mortality of 87.69% (3327 out of 3794). Most of the deaths 79.14% (2633 out of 3327) occurred within 30 minutes of the patient’s arrival to the hospital and only 694 patients lived beyond one hour of arrival.

Conclusion

Presently the quantum of outcome i.e, survival and good recovery in craniocerebral missile injuries appears a meager heap compared to the huge amount of death and disability. And the situation will continue to be so unless tertiary care hospitals are set up within and around the armed and conflict zones, war torn areas and battle fields, rather than risking transportation, time of resuscitation, intervention and the results.

INTRODUCTION

Craniocerebral missile injuries are common in military personnel in war zones but for the past few decades civilian population around the world has become vulnerable to such injuries due to civil wars, regional conflicts, militancy, terrorism and military-related operations. Management of gunshot (missile) wounds (injuries) of head (craniocerebrum) due to bullets, shotguns, blasts, explosion of grenades and mines has been a routine experience in the Neurosurgical centre, at the Sheri-I- Kashmir Institute of Medical sciences, Kashmir, India. A missile is a projectile of either a high velocity *muzzle velocity > 2000 Ft/sec* or a low velocity *muzzle velocity < 1000 Ft/sec* [6]. Projectiles are pellets fired from a shotgun, bullets from rifles, machine-guns, carbines, automatic guns and shrapnels and splinters by exploding bombs, mines and grenades. A high velocity primary missile deposits its kinetic energy on the skull, it fragments or mushrooms (deforms) with the fracture of the bone, thereby driving a number of small bone pieces (secondary missiles) into the brain tissue and furthering the damage. Also a high pressure sonic wave, lasting for microseconds (insignificant), radiates outwards from the point of primary missile impact. But more damaging to the brain tissue, adjacent and distant to track, is a low pressure, long (milliseconds) lasting wave which displaces and crushes the brain tissue radially due to moving missile in the brain [17]. This effect of tangential compression of brain tissue from primary track leads to temporary cavitation and suction of air, skin, hairs and debris into brain parenchyma. A missile (bullet or splinter) may tumble (yaw) within the brain tissue at its greatest slowing, presenting its long axis to the flight path thereby increasing primary track dimensions and secondary cavitation only to damage more brain. Such a phenomenon leads to a large exit wound with a perforating injury [16, 25]. Bullets can be blunt-nosed, half or fully jacketed and hollow tipped to increase mushrooming (deformity), to ensure more damage to the tissue of target. Dumdum and devastator bullets transmit most kinetic energy at the impact site [25]. Craniocerebral missile wounds have been classified by Cushing in World War I [15] and Matson in World War II [27]. Missile wounds are tangential, penetrating and perforating [27, 5]. Tangential wounds occur when a missile grazes the skull at an oblique angle, only lacerating the scalp or stays under scalp causing depressed or elevated fractures and indriving bone fragments into brain parenchyma causing dural tears, cortical contusions, extradural or subdural hematomas. Prognosis is good after debridement. Penetrating missile injuries occur when a projectile strikes the skull nearly perpendicular, so that less energy is needed to break the bone and flight path is primarily taken into brain tissue after a tumble. The injuries produced are contusions, lacerations, haematomas, ventricular and dural sinus injuries, arterio-venous fistulas, pseudoaneurysms and remote infarcts. The fragmentation of the bone produces secondary missiles which take different paths in the brain tissue causing more damage. Sometimes a missile after hitting opposite innertable of bone may secondarily re-enter the brain tissue in a different path (ricochet). Missiles may migrate through ventricular and dural venous sinus systems [43, 42]. A missile may travel along the innertable epidurally, after penetrating the bone, to be lodged in epidural space (careening). Perforating wounds are produced by high velocity missiles, fired at close range, causing secondary explosive cavitation due to yaw of missile, larger wounds of exit, skull base fractures, enormous rise in intracranial pressure temporarily, suction of debris, air, hair and skin into brain parenchyma, tonsillar hematomas and medullary compression as remote effects [18].

Skull X-rays and plain CT-scan are the investigative tools, latter being the only primary and practical diagnostic tool. However, MRI is contraindicated. Metallic scatter can compromise the quality of a CT-scan. Angiography is procedure of choice in patients with sylvian fissure hematomas and when missile trajectory is detected close to either middle cerebral artery complex or sylvian fissure, basal cisterns, supraclinoidal area and cavernous and other sinuses [4, 3]. Surgical management varies in technique, according to extent and depth of brain injury, from minimal, conservative and standard to radical [47, 50, 41, 9, 19].

In World War I Harvey Cushing reduced operative mortality of penetrating brain injuries from 56% to 28% in 3 months by aggressively and meticulously debriding all devitalized tissue, removing metal and bone fragments with good closure [15]. Similar low mortality of 9.7% was reported by Hammon in 1971 from the Vietnam War, in 2187 patients [20]. Since the availability of blood and antibiotics mortality is improving. Postinjury after effect like a rise in ICP, CSF-leaks, brain swelling, infections, neurodeficits, carotico-cavernous fistulas and pseudoaneurysms are correlated with morbidity and mortality. However the exact pathophysiology, anatomy, vascular and biochemical effects of brain at the time of missile entry, need to be evaluated on animal models[10].

MATERIAL AND METHODS

The Neurosurgical Centre of Sher-i-Kashmir Institute of Medical Sciences (SKIMS), Kashmir, India, caters to a 6 million ethnic, non-migratory Kashmiri population, as a single centre in the whole Kashmir valley. The, Craniocerebral missile injuries in civilian Kashmir - India, from September 1988 to September 2009 is a retrospective study. All patients were civilians who fell victim to the ongoing armed conflict. The military and army patients are always flown away from the mountainous valley of Kashmir to the different National Capital hospitals for the scare of militant strikes. Age group from 3 years to 78 years and both sexes were involved. All Injuries were due to high velocity missiles, transportation of patients was neither proper nor quick and also no field-resuscitation or airway control was taken care-of (by the laymen who brought most of the patients to the hospital). So hospital-resuscitation was the first but delayed measure in the resuscitation process of such patients. No post-mortem study was carried out in any case. After initial resuscitation, all patients were assessed by admission Glasgow Coma Scale (GCS) scoring [51] and then subjected to plain CAT-Scan. Patients were triaged in the CT-room, investigated and managed surgically and conservatively. Surgical procedures were undertaken after complete assessment of base-line investigations, neurological, hemodynamic and coagulability status of the patients. All types of surgical techniques from minimal debridement and wound closure to standard and radical procedures like craniotomy, craniectomy, removal of accessible and visualised bone, debris, skin, hair, metal fragments, pressure-building and shift-producing parenchymal and dural related hematomas and dural and scalp closure. “Minimal” type of surgery refers to the debridement of entrance and exit wounds, no chase for inaccessible bony and missile fragments and dural repair [47, 50]. “Standard” procedure, mostly practiced, is dural debridement, debridement of entrance and exit wound of necrotic and devitalised brain tissue. Removal of any intra and extraxial hematomas, all missile and bone fragments, skin, hairs, dirt and clot by irrigation and suction [32, 46]. “Radical” surgery is defined as wide debridement of missile track, of necrotic brain tissue, bone chips, missile fragments and clots, till viable and normal brain tissue is seen from entrance upto exit wound. Here a finger may be used to palpate the foreign bodies in and around the track. This leaves the missile track wide open to place an ICP monitoring catheter in the cavity [19, 49]. The ventriculostomies for Intracranial pressure monitoring was carried out in many operative and some non-operative patients. Complications were managed accordingly and as required. The survival, mortality and functional outcome were evaluated by Glasgow Outcome Scale (GOS) score [23]. The Analysis of Variance was applied where-ever possible and the SPSS 11.5 software programme used to analyse and calculate data.

RESULTS

Admission GCS and time of death

Analysis of 3794 patients showed that 74.96% (2844 out of 3794) patients had an admission GCS score 3 (Table 1). 12.99% (493 out of 3794) patients had admission GCS score 4; 8.67% (329 out of 3794) patients had GCS score 5 - 8 and about 3.37% (128 out of 3794) patients had score 9-15. Total mortality of all 3794 patients was 87.69% (3327 patients). Of total deaths (3327 patients=100%), 79.14% (2633) patients died within 30 minutes of arrival and 20.85% (694) patients died from first hour to one month. The eminent observation was that 93.17% (3100 out of 3327) of all patients who died, deteriorated so quickly that neither surgery nor satisfactory conservative treatment could be useful. However, another 6.82% (227 out of 3327) deaths occurred either postsurgical or after conservative management. The total deaths included all patients with admission GCS score 3 (2844 out of 3327) contributing 85.48% to all deaths; 11.90% (396 out of 3327) patients with GCS score 4 ; 2.6% (87 out of 3327) patients with GCS score 5-8 but no mortality was observed in the group of patients with GCS score 9-15.

Age and sex

Both sexes of all ages from 3 to 78 years were involved. The youngest was a child of 3 years who died within 1 hour of a stray-bullet fired 1 km away from target. Males were 80.73% (3063 out of 3794), females 18.08% (686 out of 3794) and 1.18% (45 out of 3794) children below 18 years (table 2). Age group of 18 - 40 years included 60.20% (2284 out of 3794) Patients with a mortality of 82.61% (1887 out of 2284) which formed 56.71% of total (3327 deaths) mortality. Age group of 41 to 78 years comprised 38.61% (1465 out of 3794) patients and had a mortality of 96.99% (1421 out of 1465) contributing 42.71% to total mortality (1421 out of 3327). Children (below 18 years) were 1.18% (45 out of 3794) with a mortality of 42.2% (19 out of 45) forming 0.57% (19 out of 3327) of total deaths. Out of all males (3063) about 94.61% (2898) died forming 87.10% (2898 out of 3327) of all deaths. Similarly out of all females (686) about 59.76% (410) died comprising 12.32% (410 out of 3327) of all deaths.

Mode of Transportation and Clinical State

Living in the circumstances, as may resemble somewhat a battlefield or a conflict zone, one of the basic impediments in rendering primary resuscitation and treatment, is delayed and poor way of transportation. Additionally, lack of trained-drivers, trained-staff and resuscitation-kits in ambulances equates the transportation with delayed or incomplete resuscitation. The clinical state of patients, on arrival to the hospital, suggested that the mode of transportation had influenced adversely the vital signs of most. The unknown and laymen or angry mob and common -masses or relatives had out numbered the local police and paramedical personnel in accompanying the patients to the hospital (Table 3). About 63% (2391 out of 3794) patients were accompanied by laymen, of which 89.2% (2133 out of 2391) patients died, comprising 64.11% (2133 out of 3327) of total deaths. Local police accompanied 21% (800 out of 3794) patients, of which 89.6% (717 out of 800) died, comprising 21.55% (717 out of 3327) of all deaths. Laymen accompanied 60.30% (1715 out of 2844) of all patients with admission GCS score 3. Out of 3137 patients with abnormal but spontaneous breathing at admission, 65.22% (2046 out of 3137) were brought by common masses. Apnea and hypotension were also common in patients brought by relatives and angry mob. Apnea was found in 58.67% (345 out of 588) patients and 65.59 % (1870 out of 2851) had hypotension of SBP < 90 mmHg at admission. All patients with admission GCS score 3 and 80% patients with admission GCS score 4 brought by laymen, angry mob or relatives had bilaterally fixed dilated pupils. Coagulopathy was found in 21% (797 out of 3794) patients with 74.9% (597 out of 797) mortality. Referrals and transportation from other Central and peripheral hospitals of Kashmir had an equal and adverse influence on the morbidity and mortality, whether a hospital or a non-hospital carrier transported them, if the patient was un-intubated or not tracheostomised. Dramatic influence on the clinical state was seen if the referred patient was intubated or tracheostomised and accompanying person was a trained staff. Other hospitals referred 603 craniocerebral missile injuries but only 11.4% (69 out of 603) patients were intubated, of which > 37 % (26 out of 69) survived, and a mortality of 79.1% (477 out of 603) occured which comprised 14.33% of total (3327) deaths (Table 3).

Imaging

X-rays of the skull demonstrated bone defects, fractures, pneumocephalus and intact or fragmented missiles (Fig 1, 2). Plain CAT-scan head, performed in all patients, revealed direct relationship between severity of intracranial injury, admission GCS score 3-5 and mortality (Table 4). The patients with admission GCS score 3 (2844 out of 3794) had intracranial hematomas in 33.86% (963 out of 2844), subarachnoid hemorrhage in 89.13% (2535 out of 2844), ventricular hemorrhage in 56.5% (1607 out of 2844) and midline shift in 41.56% (1182 out of 2844). All these (2844) patients died. Intracranial hematomas like epidural, subdural and intracerebral were found in 40.19% (1525 out of 3794) of all patients. Subarachnoid hemorrhage (SAH) was found in 79.6% (3021 out of 3794) of all patients with 97.6% deaths, ventricular hemorrhage in 48.6% (1847 out of 3794) with 99.5% deaths, pneumocephalus in 49.6% (1883 out of 3794) and midline shift in 45.7%

(1736 out of 3794) patients. Evidence of missile and bone fragments was found in 35.13% (1333 out of 3794) patients. Similar findings were found in the group of 493 (out of 3794) patients with admission GCS score 4, which had a mortality of 80.32% (396 out of 493). Patients with admission GCS 5 and above (457 out of 3794) with all or some of the above CT-findings, responded better to the resuscitation and wound debridement. All of these patients had some midline shift and 19% (87 out of 457) died. Patients with admission GCS score 3 and 4 together had a mortality of 97.38% (3240 out of 3327). Angiography, performed on 121 patients, revealed 17.3% (21 out of 121) dural venous sinus tears, 12.3% (15 out of 121) pseudoaneurysms and 1.6% (2 out of 121) carotico-cavernous fistulas (Table 4). Vasospasm was found in about 29.7% (36 out of 121) patients (Fig 3).

Missile Tracks and Scalp Wounds

Missile track extensions and directions depend upon the velocity and size of the missiles, angle at which these strike the skull and thickness of the bone (Fig 4, 8). CT-scan brain revealed missile tracks in relation to scalp wounds and severity of brain injury could be predicted from scalp wound site (Table 5). The most lethal wounds were occipital ones with 100% (114 out of 114) mortality followed by 97.8% (916 out of 936) in temporal and 94.7% (1511 out of 1595) mortality in frontal wounds . Least fatality of 65.8% (623 out of 962) was observed among parietal wounds. Top parietal scalp wounds, even if bilateral, except dural venous sinus tears, had better post resuscitation outcome (Fig 4). The orbito-nasal wounds had poor prognosis with 81.8% (153 out of 187) mortality. Missile tracks crossed from infratentorial to supratentorial compartment in 88.37% (76 out of 86) patients of uni-occipital scalp wounds and all of these had multilobar injuries. About

17.4% (15 out of 86) had injured both cerebral hemispheres after injuring cerebellum of same side of occipital wound (referred to as Tri-hemispheric injury) and all of these patients died. All those 68.6% (59 out of 86) ventricular and 82.5% (71 out of 86) brainstem injuries, which were found in relation with uni-occipital wounds, died. Equally fatal were mid occipital and bi-occipital wounds. Patients with bi-temporal wounds, in which CT-Scan revealed missile tracks crossing both hemispheres and multilobar hemorrhages, carried 100% (315 out of 315) mortality. Brainstem, on imaging, appeared grossly spared in 97.4% (307 out of 315) patients of ventricular injuries. Multilobar injuries were revealed in 73.4 % (2785 out of 3794) patients with 90% (2506 out of 2785) mortality; bihemispheric injuries in 73.1% (2777 out of 3794) with 93.3% (2591 out of 2777) mortality; ventricular injuries in 48.6% (1847 out of 3794) with 99.5% (1838 out of 1847) mortality and subarachnoid hemorrhage in 79.6% (3021 out of 3794) with 97.6% (2949 out of 3021) mortality. Assessment of scalp wounds predicted the possible amount and magnitude of injury to the brain parenchyma. However, true picture of injury can only be revealed by an axial and spiral CT-scan and sometimes reformative reconstruction of axial images into sagittal and coronal planes.

Triage and ICP Monitoring

Immediately following resuscitation, on ABC-guidelines, and quick respiratory and pupillary assessment, admission GCS scoring, haemodynamic monitoring, scalp wound and CT assessment of brain injury, the CT-room triaging was conducted routinely in all cases. Patients were selected either for surgical procedures (as indicated in the material and methods) or for conservative treatment and controlled ventilation. Compatible blood transfusion, treatment of coagulopathy and shock, antibiotics and anticonvulsant were liberally used. Intracranial pressure (ICP) monitoring was performed in 207 patients. Monitoring devices were placed either in ventricular system or within the intraparenchymal cavities created after evacuation of blood-clots. Postoperatively, ICP monitoring was conducted on 171 (out of 207) patients and 36 (out of 207) patients from a conservatively managed group. This included 168 (out of 207) patients from admission GCS score 3-5 group and 39 (out of207) from GCS score 6-15 group. An ICP of more than 20mmHg in any patient was treated either by therapeutic drainage of CSF or by decongestants. All 39 patients from admission GCS score 6-15 group survived and also 105 (out of 168) patients from GCS score 4-5 were salvageable, while none from GCS score 3 lived.

Surgical Treatment

All patients required wound cleaning and repair of scalp or skin but only 585 patients, who required haemostasis , debridement of devitalised brain , repair of dura and skin , evacuation of clots and removal of accessible and visible missiles and bone fragments , were selected for surgery (Table 6). A total of 109 patients , who were haemodynamically unstable, had coagulopathy, some were admission GCS score 3 with bilateral fixed and dilated pupils, or had any GCS score with no gross dural tear even in presence of indriven bone and metal pieces, no clots or midline shift visualised on CT-scan, were not operated. This conservative group had 42.2% (46 -included all GCS 3 patients - out of 109) mortality. Among operative group of 585 patients , 42.6% (249 out of 585) were males, 52.6% (308 out of 585) females and 4.8% (28 out of 585) children. All the 35 males and 3 females with presurgical GCS score 3 died. Mortality of 92 Patients with presurgical GCS score 4, was 42.4% (39 out of 92). However, no mortality was found in patients with presurgical GCS score 9- 15. The choice of surgical procedure was made on the type of brain injury .The most practiced operative procedure was, ‘standard’ procedure in 70.9% (415 out of 585) patients. The “radical” operative procedure was carried out in 16.5% (97 out of 585) and “minimal” operative procedure in 12.4% (73 out of 585) patients. A surgical mortality of 30.9% (181 out of 585) for all procedures was observed. The age and sex distribution of postoperative mortality (181 deaths) revealed that 60.2% (109 out

of 181) were males, 38.6% (70 out of 181) females and 1.1% (2 out of 181) children. Survival figures of 92.8% (26 out of 28) for children and 77.2% (238 out of 308) for females were recorded. But only 56.2% males survived postoperatively. The group of patients with admission GCS score 4 to 8 was most salvageable surgically, with a survival of 65.87% (276 out of 419). Most of these underwent ‘standard’ surgical procedure. All accessible fragmented and intact missiles and bones were removed. The intraoperative ultrasonography was used to locate and sometimes finger used (as much as missile-track allowed) to palpate the missiles and bone. All hairs, skin, debris, and dirt was removed by saline irrigation and rest of the procedure completed after water tight dural closure.

Missile Recovery

No attempts were made, to chase or palpate any indriven inaccessible bone and missile fragments, to avoid any insult to normal and uninjured brain. The missiles recovered from brain tissue were of different sizes, shapes, weights and material (metallic and non-metallic). Some rubber and metal bullets, plastic tear-gas shells and pellets were intact but others deformed, mushroomed and fragmented (Fig 5). The longest missile recovered was a bullet of more than 30mm length, 16 gm in weight and 14 mm in diameter. Heaviest missile was a mushroomed bolt, 26 gm in weight. Smallest pellet was less than 1 gm in weight. Other than metal missiles, vegetative missiles were also removed from temporal and parietal lobe injuries. Yellow Wooden-pieces of pulped mulberry stem and cardboard pieces used in shot-guns to reduce pellet scatter, were recovered from brain tissue. The largest missile was part of a white plastic tear-gas shell (Fig. 6) and softest a red rubber bullet (Fig 7).

Missile Migration

A patient coughed out a missile fragment from his mouth, which got dislodged from pituitary fossa by eroding dura, lamina dura and floor of sphenoid air sinus (Fig 8). It was noted that heavier missiles and their fragments moved along white matter tracts more frequently and freely than within the cortical tissue. Migration was also seen through ventricular and venous sinus systems and base of skull (pituitary fossa and sphenoid air sinus). Most responsible factors for the migration observed were positional, gravity, brain pulsations, frictionless missile surface, tissue necrosis around the missile and absorption of metal from missile surface. In three of the patients missiles came to rest at one spot in brain, either after complete cordoning-off by gliosis or by formation of abscess.

Complications and Mortality

A total of 550 complications were observed in 694 patients with 32.7% (227 out of 694) deaths. Postoperatively, 460 complications were observed in 585 patients with 30.9% (181 out of 585) mortality. Most common postoperative complication observed was brain swelling with midline shift in 207 patients with 53.14% (110 out of 207) mortality (Table 7). The only patient of carotico-cavernous fistula (CCF) died. Wound infection occurred in 127 patients with 31.4% (40 out of 127) mortality. There were 90 complications observed in conservative-group of 109 patients with 42.2% (46 - which included all GCS 3 patients - out of 109) mortality. The common complication, in conservative group of 109 patients, was brain swelling and midline shift occurring in 22 patients with 90.9% (20 out of 22) mortality. Meningitis and brain abscess together caused 38.46% (25 out of 65) mortality in both the conservative and operative groups. CSF-fistulas had a mortality of 8% (4 out of 50) from both the groups (conservative 1 out of 5 ; postoperative 3 out of 45). Disseminated intravascular coagulation (DIC) was observed in 19 patients from both groups (operative and conservative) with 84.2% (16 out of 19) mortality. Also complications like missile migration, seizures, hydrocephalus, pseudoaneurysms and cortical atrophy were observed. Noteworthy was to observe cortical atrophy excessively in patients with pneumocephalus on a longer follow-up. Even wound infection was found more in patients with pneumocephalus at the time of admission. A patient with pseudoaneurysm developed a rare complication of trigeminal neuralgia (Table 7).

Outcome

The currently used and widely accepted Glasgow Outcome Scale - GOS (Jennett et al; 1975) was applied to assess the recovery, disability and death of patients (Table 8). A total of 67.2% (467 out of 694) patients survived and 32.7% (227 out of 694) died. Good outcome was observed in 37.6% (176 out of 467) of all survived patients. None of those patients who had admission GCS score 4, lived with good recovery. Moderate disability was seen in 29.5% (138 out of 467) and severe disability in 20.12% (94 out of 467) patients. The condition of permanent-vegetative state occurred in 12.60% (59 out of 467) of surviving patients. All patients with GCS score 3 died, both from surgical and conservative groups. No mortality was observed in the GCS score 9-15 group.

DISCUSSION

It is interesting to note that any two patients of craniocerebral missile injuries , with same age, sex and same CT-scan findings, present with a different clinical picture from each other and respond to resuscitation so differently. Underlying neuronal injury due to physical, chemical, thermal and sonic trauma may be much varied than may appear in every individual case.

Age and Sex

Sherman et al (1980) noted that 70% of elderly patients died but the young group of 21-40 years had only 15% mortality [46].Similar findings were reported by Suddaby et al (1987), Kaufman et al (1986) and Narayan et al in 1992 [50, 24, 39]. The study at SKIMS, Kashmir observed less mortality in 18-40 years age group in both sexes, than in age group above 41 years. However, females and children survived more often than males, but young males outnumbered females and children in total injuries which is similar to the reports of above reporters.

TIME OF ADMISSION AND DEATH

Byrnes et al (1974), in Northern Ireland series have shown high mortality of 57% despite quick admission within 30 minutes and surgical treatment within 2 to 4 hours [9]. Rapid transport of victims with very severe injury to hospital has shown paradoxical high hospital mortality [32, 22]. Analysis at SKIMS, Kashmir shows that a mortality of 79.14% (2633 out of 3327 deaths) occurred within 30 minutes of admission and most (2355 out of 2633) deaths had admission GCS score 3. However, total mortality from 30 minutes of admission to 1 month was 87.7% (3327 out of 3794).But most of the deaths, 79.14% (2633 out of 3327) took place within 30 minutes of admission. Next, 20.60% (685 out of 3327) died within 12 hours and rest of the 0.3% (9 out of 3327) deaths upto one month of admission. Only 694 patients lived beyond 1 hour , out of which 585 patients needed surgical intervention with 30.9% (181 out of 585) mortality and 109 patients were managed conservatively, with 42.2% (46 out of 109) deaths. Freytag (1963) noted in her autopsy study that 63% of gunshot wound victims dead on arrival at hospital, 27% died within 24 hours and only 10% lived more than a day [18]. Kaufman et al (1986), noted 71% of all victims dead at the scene, another 14% died within 5 hours, 13% died between 5 and 48 hours and less than 2% survived longer than 48 hours [24].

SURGICAL DEATHS

Grahm et al (1990), had an operative mortality of 23% and overall mortality of those admitted was 63%. All of his patients received the same aggressive care irrespective of GCS score [19]. However, Levy (2000) reported no clear benefit in patients with GCS score 6 to 8 , but assured that more patients could be salvageable when the GCS is 6-8 than when it is 3-5 [29]. In the Kashmir series, an overall mortality of 87.69% and 30.9% postoperative mortality was observed. Although, 65.87% (276 out of 419), patients from the GCS score 4-8 group were surgically salvageable.

TRANSPORTATION AND RESUSCITATION

The need for a rapid, military-like, evacuation-scheme for the craniocerebral missile injuries has been reported. Army resuscitation and evacuation techniques pioneered in the world war II and Korean war and perfected in Vietnam war in 1960s [41, 9, 7]. Poor mode of transportation caused neurological deterioration in 89 gunshot wound patients of Raimondi and Samuelson in 1970. Only 2 of 89 patients were tracheostomized and none had an endotracheal tube in place before or during transport. When initially seen 45 of 89 patients were alert and only 6 were posturing, but only 36 were alert and 22 were decerebrating when received at neurosurgical centre [41]. However Byrnes et al (1974) stated that resuscitation within minutes of injury, great care taken by field medical workers to maintain airway using intubation, quick transportation and admission to hospital, transfusion of blood to combat hypotension and controlled ventilation caused improvement in neurological status in contrast to neurological deterioration during transport [9]. Other reports also indicated the development of programmes ensuring vigorous field resuscitation and rapid transport to a neurosurgical centre [19, 24, 44, 37, 28, 31]. Analysis of 3794 patients at SKIMS Kashmir, revealed neurological deterioration while transportation in the hands of laymen. The bystanders, common masses, angry mob, unknown and laymen carried 2391 of all 3794 patients, of which 2133 died. Police personnel accompanied 800 victims, of which 717 died. There were 603 delayed referrals from other hospitals which were transported in a poor clinical state, for only 69 patients were intubated most of which survived and 477 died. Clinical deterioration in the form of hypotension (2851 out of 3794 patients), abnormal respiration (3137 out of 3794 patients) and apnea (588 out of 3794) was evident. Chestnut et al (1993) and Miller et al (1982) suggested adverse outcome in closed head injury with hypotension of systolic blood pressure (SBP) less than 90 mmHg [12, 36]. Byrnes et al (1974) observed 72% mortality in hypotension and Suddaby et al (1987) observed 80%, whereas Aldrich et al (1992) had observed 84% mortality [50, 9, 1]. Even postresuscitation intracranial hypertension was associated with poor outcome [8].

LEVEL OF CONSCIOUSNESS

Clark et al(1986) showed that all 33 patients of gunshot wounds with GCS score of 3 and 4 were not considered for surgery and had high mortality [13]. A study of series of gunshot wounds in civilians were analysed by some workers and correlated level of consciousness based on GCS score with mortality. The results revealed that patients with GCS score 3 -5 had 94% and GCS score 6-8 had 59% mortality. Their series showed a mortality of 15% in GCS score 9-12 and 3% in GCS score 13-15 [19, 24, 44, 28, 38, 11, 33, 48]. The SKIMS, Kashmir study revealed 100% mortality in admission GCS score 3; 80.3% in GCS score 4; 43.5% in GCS score 5; 28% in GCS score 6; 20% in GCS score 7; 6.5% in GCS score 8 and no mortality in GCS score 9-15. The study of a series of reporters analysed that the patients who showed signs of

decortications and decerebration or flaccid posture to painful stimuli had 95% mortality [47, 41, 9, 46, 32, 22, 7, 52]. PUPILS: The SKIMS, Kashmir analysis showed that all patients with admission GCS score 3 had fixed dilated pupils and some victims in admission GCS score 4-5 had normal size and reactive pupils. Bilateral dilated and fixed pupils carried bad prognosis. But there are varied reports regarding the predictability of outcome on the basis of pupils [50, 9, 19, 23, 22].

IMAGING

Levy et al (1993) documented 1% incidence of pseudoaneurysms following bullet wounding and 3.2% when SAH was demonstrated by angiography [30]. Benzel et al(1991) advises angiography if missile trajectory traverses through sylvian fissure, middle cerebral artery complex and delayed sudden deterioration, to exclude development of a possible pseudoaneurysm [7]. Raimondi et al (1970) have also advised and found similar findings [41]. Analysis at SKIMS, Kashmir revealed that 17% dural venous sinus tears, 12% pseudoaneurysms and 1.6% carotico-cavernous fistula (CCF) were demonstrated by angiography of 121 patients.

COMPUTED TOMOGRAPHY

The linear and depressed fractures, intracranial and intraparenchymal hemorrhages, bone, metal, air, missile track, infarct, midline shift, CCF, pseudoaneurysms, sinus tears, hydrocephalus and brain abscesses can easily be demonstrated on this primary diagnostic tool. CT-scan demonstration of missile tracks crossing midsagittal plane had 40% mortality, 53% when it crossed midcoronal plane and 75% when both planes were crossed. One lobe injury lead to 23% deaths [47, 50, 46, 32, 30, 14]. Further in one lobe injury Shoung et al (1985) has 20% deaths, Cavaliere et al (1988)- 76%, Selden et al (1988)- 45%, Levi et al (1991)- 20% and Siccardi et al (1991)- 77% deaths . Mortality in missile tracks crossing midsagittal plane ranges from 50% to 98% in all above studies [47, 44, 28, 11, 48]. Grahm et al(1990) showed 90% mortality and 10% neurologic devastation in bihemispheric and transventricular penetrating tracks [19]. Suddaby et al (1987) and Kaufman et al (1986) revealed poor outcome (50% mortality) in patients with midline shift while Aldrich et al (1992) had 80% mortality [50, 24, 1]. Similarly missile fragmentation carried bad prognosis as regard the reports of Nagib et al (1986) and Levy et al in 1994 [31, 38]. Rare complication like intracerebral migration of metallic fragments is reported [2]. All types of intracranial bleeds are common. Helling et al (1992) reported 4% Intracerebral hemorrhages and Levi et al (1991) reported 37% [21]. The intraventricular hemorrhages as reported by Helling et al (1992) are 56% common and subarachnoid hemorrhages reported by Stone et al (1995) are 9%, Aldrich et al (1992)- 78%, Shoung et al (1985)- 59% and Levy et al (1993) reported in 31% patients [47, 1, 30, 21, 49]. Mortality in SAH as reported by Levy et al (1993) is 68%, Stone et al (1995) - 65% and Aldrich et al (1992) 81% common [1, 30, 49]. The Study at SKIMS, Kashmir, analysed X-ray skull and CT-scans of all the victims before triaging, including those who died soon after arrival. The X-rays reveal a global view of the skull and demonstrate missiles, fractures and defects in bone. The plain CT-scan is worth more than any other imaging in such injuries. Other than revealing all types of vault and basal fractures, intracranial and intraparenchymal hematomas, midline shift, missile tracks, bone, metal, air, abscess etc..., it has also depicted vegetative (wooden yellow pulped-mulberry stem and cardboard) wads (fig 6) as hypodense areas. The wads are used in shotguns to reduce early scatter of pellets. At close range shooting, wads along with pellets enters the brain tissue to further the damage. Analysis of 3794 cases at SKIMS in Kashmir revealed subarachnoid hemorrhage in 79% with 97.6% mortality, ventricular hemorrhage in 48.6% with 99.5% mortality, pneumocephalus in 49.6% and midline shift in 45.7%. The multilobar injuries were found in 73.4% with 90% mortality and bihemispheric injuries in 73.1% with about 94% mortality was observed. The Scalp wounds were analysed and uni-occipital wounds were found most fatal, where missile track crossed both tentorial compartments and some of these wounds were bihemispheric (referred to as tri-hemispheric when associated with cerebellar injury) with 100% mortality. The temporal and frontal wounds carried bad prognosis with 97.8% and 94.7% mortality respectively.

PREDICTORS OF MORTALITY

The analysis of 3794 patients at SKIMS, Kashmir shows that strong predictors of mortality and poor outcome are admission GCS score 3 and 4, delayed and poor mode of transportation, apnea at admission, haemodynamic instability (hypotension), bilateral fixed dilated pupils, ventricular and subarachnoid hemorrhage, missile track crossing bihemispheric, bitentorial (or trihemispheric) compartments and multilobar injuries, disseminated intravascular coagulation (DIC), advanced age, postoperative rise in ICP and associated injuries to chest, abdomen and great vessels. However, scalp wounds have a bearing on type and extension of intracranial or intraparenchymal injury but may not correlate at times, as in tangential injuries (gun - graze). Several investigators have related similar clinical and CT findings to mortality, after using statistical tests [31, 1, 49, 45, 40].

ICP-MONITORING

Intracranial pressure (ICP) monitoring is used to determine cerebral perfusion pressure in some patients. A series of many authors shows that all those patients who had mean ICP 62 mmHg died and mean ICP 31 mmHg lived . ICP is thought to be only second to GCS scoring as the predictor of outcome [47, 9, 19, 46, 24, 32, 37, 1]. The analysis at SKIMS, Kashmir showed that a total of 207 patients, 171 postoperatively and

36 unoperated, were subjected to ICP monitoring. The monitoring devices were placed in ventricular system and intraparenchymal cavities, created after clot evacuation. The admission GCS score of 168 patients was 3-5 (only 105 survived) and 39 had admission GCS score 6-15, all of these survived. An ICP of more than 20 mmHg was controlled by therapeutic drainage of CSF and decongestants.

SURGICAL TREATMENT

At SKIMS, Kashmir 109 patients were managed conservatively and ventilated electively. Some of these were patients with bilaterally fixed dilated pupils and admission GCS score 3, some haemodynamically unstable (hypotension- SBP <90 mmHg), in coagulopathy, indriven intraparenchymal bone and missile fragments with no gross dural tear with various GCS score. The mortality of these patients (109) was 42.2% (46 - including all GCS 3 - out of 109). The goals of surgery were haemostasis, debridement to reduce ICP and infections after closure, evacuation of a clot causing mass effect or midline shift and repair of dura and scalp. Surgical mortality was 30.9% (181 out of 585 patients). All 38 patients from GCS score 3 group died postoperatively. Most of the patients (71%) were benefited by standard surgical procedure (415 out of 585). Only 12.4% (73 out of 585) patients were subjected to minimal procedure and radical procedure was practiced upon 16.5% (97 out of 585) patients. The admission GCS score 4-8 group had, most, 65.87% (276 out of 419) survival with standard surgical procedures. Levy et al (1994) operated upon 190 patients with GCS scores of 3, 4 and 5, if these were normotensive with reactive pupils [32]. Stone et al (1995) used post resucitation GCS score plus haemodynamic stability as the primary criteria for surgery, with 21% mortality [49]. Hubschmann et al (1979) operated with standard procedures on patients with lesser neurodefict and if mass lesion would be suspected intracranially, with 43% mortality [22]. Sherman et al (1980) excluded those from surgery who had apnea and no brainstem reflexes [46]. Shoung et al (1985) did not operate upon decerebrating or flaccid patients [47]. Kaufman et al (1986) had 55% mortality with standard approaches [24]. Grahm et al (1990) was aggressive in treating post resuscitation patients, who had intact motor movements (like reactive pupils, intact corneal, cough or gag reflex) plus spontaneous respiration, with 23% surgical mortality [19]. Cavaliere et al (1988) operated only on patients with a GCS score of 6 and more, while Siccardi et al (1991) on GCS score 4 [11, 48]. The surgical mortality of GCS score 3-5 has been 80%, GCS score 6-8 - 59%, GCS score 9-12 - 15% and GCS score 13-15 had 3% [19, 24, 11, 33, 48]. The standard procedure was advocated by Lillard (1978) with 33% mortality [32]. Minimal debridement was carried out by Shoung et al (1985), Suddaby et al (1987) and Levi et al in 1991 [47, 50, 28]. Even if conservative approach was also a procedure advocated by Raimondi et al (1970), Yashon et al (1972) and Hubschmann et al (1979), it seemed much similar to standard procedure [41, 22, 52]. However Grahm et al (1990) was aggressive and his procedure was radical [19]. Raimondi et al (1970) had 16% mortality with the conservative approach [41]. Brain infections (meningitis and brain abscesses) were most common types of complications and resulted in 29% mortality. CSF-leaks occurred as frequently as brain infections but with only 8% mortality. Wound and bone-flap infections occurred in 14% patients without any deaths, as reported by some investigators [50, 9, 46, 32, 13, 38, 52].

Reports like post debridement infections, retained bone fragments, sinus injury and cerebrospinal fluid (CSF) leaks are related to each other, have been commonly found in literature [50, 46, 32, 28, 38, 52]. The Infective potential of bone fragments was shown by Martin et al (1946) in Vietnam war [34]. Levy (2000) reported 85% mortality in disseminated intravascular coagulation (DIC) in a study [29]. Kluger (2003) has reported recovery of bolts weighing 25 g from brain tissue in terrorist bombing [26]. The Analysis of 3794 patients at SKIMS, Kashmir showed that brain infections had a mortality of 38.46% and CSF-leaks had 8% while DIC lead to 84.2% deaths. Also it was found that, rather than bone and metal fragments, more responsible factors for delayed brain and wound infections were pneumocephalus, intraparenchymal hairs, skin undetectd by imaging, delay in wound debridement, closure, intraparenchymal rubber bullets, plastic tear-gas shells, wooden (pulped-mulberry) and cardboard wads (non-metallic missiles). Along with retained bone and metal fragments, all above were also epileptogenic in origin. The heaviest deformed missile fragment (a bolt) recovered was 26 g in weight (Fig 6). Millar et al (1975) reported rubber bullet injuries to the head and neck most frequent and severe in a series of 90 cases [35].

OUTCOME

Nagib et al (1986), Grahm et al (1990), Levi et al (1991) and Aldrich et al (1992) showed that assessment of GCS score 3 - 5 patients with Glasgow Outcome Scale (GOS) revealed 90% mortality, 3% persistent vegetative state, 5% severe disability, 2% moderate disability and only 0.2% good outcome [19, 28, 1, 38]. Application of this scale to the study at SKIMS, Kashmir revealed that post operative and conservatively managed patients had a mortality of 32.7% (227 out of 694) and admission GCS score 3 had 100% (55 out of 55) deaths. A mortality of about 56.47% (157 out of 278) was observed in admission GCS 3-5 group (including 100% morality in GCS 3 group). The persistent vegetative state was found in 8.50% (59 out of 694) and severe disability in 13.5% (94 out of 694) patients. The moderate disability was observed in 19.8% (138 out of 694) and good recovery found in 25.3% (176 out of 694) patients.

To conclude, presently the quantum of survival and good recovery in craniocerebral missile injuries appears a meagre heap infront of the mountain huge amount of death and disability in developing and third world countries like ours. And the situation will continue to be so unless tertiary care hospitals are set up within and around the armed and conflict zones, war torn areas and battle fields, rather than waiting for and risking time and mode of transportation, time of resuscitation and intervention and the results.

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Table 1. Glasgow Coma Scale (GCS) Score and Time of Death

Admission GCS	No. of patients	Males 18 yrs.and above	Females 18 yrs.and above	Children below 18 years	Death at 10mn of arrival	1h	2h	12h	24h to 1 months	Deaths		Survival
3	2844	2610	219	15	2355	305	138	46	0	2844		0
4	493	291	198	4	268	63	52	8	5	396		97
5	108	20	85	3	6	13	12	16	0	47		61
6	75	18	55	2	3	5	4	6	3	21		54
7	70	32	36	2	1	4	3	6	0	14		56
8	76	46	27	3	0	1	0	3	1	5		71
9-12	91	35	49	7	0	0	0	0	0	0		91
13-15	37	11	17	9	0	0	0	0	0	0		37
Total	**3794**	**3063**	**686**	**45**	**2633**	**391**	**209**	**85**	**9**	**3327 / 87.69%**	**467**	

P value < 0.0001

Table 2. Mortality and Survival Related to Age and Sex

Age in Years	No. of Patients		Dead		Survived	
	Male	Female	Male	Female	Male	Female
18 to 40	1778	506	1633	254	145	252
41 to 78	1285	180	1265	156	20	24
Total	3063	686	2898	410	165	276
Children < 18 Years	45		19		26	
Grand Total	3794		3327		467	

The youngest was a child of 3 years
The oldest patient was a 78 years male

Table 3. Mode of Transportation, Clinical State and Mortality

Mode	No. of Patients	GCS at Admission 3	4	5	6- 8	9-12	13-15	Respiration Abnormal Spontanous	Apnea	Intubated	Haemodynamic Status Normal	Hypotension	Hypertension	Mortality
Laymen	1079	791	130	21	103	27	7	944	135	0	0	749	330	992
Angry Mob	713	503	117	15	55	18	5	686	27	0	0	611	102	667
Relatives	599	421	105	18	41	8	6	416	183	0	0	510	89	474
Local Police	800	655	95	20	12	12	6	728	72	0	0	615	185	717
Refferal from Hospitals														
a. Hospital Carrier		162	28	14	4	17	5							
(i). Trained Staff	111	85	8	5	4	7	2	41	1	69	42	51	18	85
(ii). Relatives	119	77	20	9	0	10	3	110	9	0	15	40	64	82
b. Non Hospital Carrier	373	312	18	20	6	9	8	212	161	0	0	275	98	310
(i). Relatives														
Total	**3794**	**2844**	**493**	**108**	**221**	**91**	**37**	**3137**	**588**	**69**	**57**	**2851**	**886**	**3327**

P value < 0.0001

Table 4. ADMISSION GCS, IMAGING AND MORTALITY

Admission GCS	No. of Patients	CT-FINDINGS Intracranial Hemorrhage	Subarachnoid Hemorrhage	Ventricular Hemorrhage	Missile and Bone Fragments	Pneumocephalus	Midline Shift	ANGIOGRAPHY* Pseudoaneurysms	Carotico-Cavernous Fistula	Dural Venous Sinus Tear	MORTALITY
3	2844	963	2535	1607	834	1303	1182	0	0	0	2844
4	493	198	315	167	255	370	97	0	0	15	396
5	108	108	52	31	71	60	108	5	1	6	47
6	75	70	40	14	54	48	75	4	0	0	21
7	70	67	32	15	31	29	70	2	0	0	14
8	76	59	30	9	35	32	76	3	1	0	5
9-12	91	41	15	3	41	37	91	1	0	0	0
13-15	37	19	2	1	12	4	37	0	0	0	0
TOTAL	**3794**	**1525**	**3021 / 80.00%**	**1847 / 49.00%**	**1333**	**1883 / 49.63%**	**1736**	**15**	**2**	**21**	**3327**

*Angiography was performed on 121 patients
p value < 0.0005

Table 5. SCALP WOUND RELATED TO CT - VISUALISATION OF MISSILE TRACK AND MORTALITY

No. & Site of Wounds	No. of Patients	Bi-tentorial Track	Bi-hemispheric Track	Uni-lobar Injury	Multi-lobar Injury	Ventricular Injury	Brain Stem Injury	Mortality
Uni-frontal	714	338	523	109	597	42	0	678
Bi-frontal	520	0	520	0	520	176	0	491
Mid Frontal	361	181	48	56	51	207	0	342
Uni-Temporal	621	110	502	285	217	495	0	601
Bi-Temporal	315	0	315	0	315	307	0	315
Uni-Parietal	437	12	301	105	332	209	0	292
Bi-Parietal	320	0	320	0	320	115	0	172
Mid Parietal	205	0	102	47	158	60	0	169
Uni-Occipital	86	76	15*	10	76	59	71	86
Bi-Occipital	23	5	0	0	23	23	23	23
Mid Occipital	5	5	0	0	5	5	5	5
Orbito-Nasal	187	169	131	16	171	149	53	153
TOTAL	**3794**	**896**	**2777**	**628**	**2785**	**1847**	**152**	**3327**

P value < 0.0001
* Cases which had bihemispheric injury in supratentorial compartment,along with cerebellar injury (infratentorially) were referred to as Trihemispheric injury

Table 6. SURGICAL MORTALITY RELATED TO GCS SCORE AND SEX

Pre-surgical GCS	No. of Patients	Males	Females	Children	Surgical Procedure Minimal	Standard	Radical	Post Surgical Mortality Male	Female	Children	Total	Survival
3	38	35	3	0	13	5	20	35	3	0	38	0
4	92	52	37	3	0	81	11	28	10	1	39	53
5	106	20	84	2	3	94	9	17	28	0	45	61
6	75	18	55	2	4	63	8	9	19	1	29	46
7	70	32	36	2	2	58	10	15	9	0	24	46
8	76	46	27	3	2	61	13	5	1	0	6	70
9-12	91	35	49	7	32	35	24	0	0	0	0	91
13-15	37	11	17	9	17	18	2	0	0	0	0	37
Total	**585**	**249**	**308**	**28**	**73**	**415**	**97**	**109** *43.70%*	**70** *22.70%*	**2** *7.10%*	**181** *30.90%*	**404** *69.10%*

P value < 0.0005

Table 7. COMPLICATIONS AND MORTALITY

Variables	Post Operative No. of Complications	No. of Deaths	Un-Operated No. of Complications	No. of Deaths	Total Number of Patients
Wound Infections	127	40	10	8	137
Brain Swelling with Midline Shift	207	110	22	20	229
Meningitis	36	12	8	5	44
CSF-Fistulas	45	3	5	1	50
Brain Abscess	18	6	3	2	21
Hydrocephalus	14	2	12	0	26
Pseudoaneurysms (Trigeminal neuralgia)	1	0	2	1	3
Carotico - Cavernous Fistula	1	1	0	0	1
Disseminated Intravascular Coagulation (DIC)	8	7	11	9	19
Seizures and Cortical Atrophy	3	0	17	0	20
Total	**460**	**181**	**90**	**46**	**550**

•585 Patients operated with 460 complications and 181 deaths
•109 Patients managed conservatively with 90 complications and 46 deaths
•One patient with pseudoaneurysm developed trigeminal (Vn) neuralgia.

Table 8. OUTCOME AS A FUNCTION OF GCS SCORE

Admission GCS Score	Glasgow Outcome Scale (GOS) Good OutCome	Moderate Disability	Severe Disability	Permanent Vegetative State	Dead Operative	Non-operative	Total
3	0	0	0	0	38	17	55
4	0	3	22	31	39	10	105
5	8	9	26	22	45	8	118
6	14	21	13	6	29	6	89
7	16	30	10	0	24	4	84
8	37	29	14	0	6	1	87
9-12	49	38	9	0	0	0	96
13-15	52	8	0	0	0	0	60
Total	176	138	94	59	181 / 30.90%	46 / 42.20%	694
	467				227	32.7% of 694	

P value < 0.0005

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