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Penetrating Craniocerebral Injuries from the Former Yugoslavia Battlefields

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Abstract : In the period from September 10th 1991 to December 31st 1992, the total of 162 patients with penetrating craniocerebral war injuries from the former Yugoslavia battlefields were treated in the Military Medical Academy (MMA) in Belgrade. The severity of injury was graded according to the Glasgow Coma Score (GCS) as mild (13-15), moderate (9-12), and severe (3-8). The extensity of the cerebral lesion was classified as unilobar, multilobar, bihemispheric, transventricular, and haematoma with shift. Injuries were divided into those caused by bullets or shrapnel. According to the missile path, these were tangential, uncrossed, and crossed injuries. The patients were divided into the two groups according to the treatment that they received: Group A- 90 patients who were referred directly to the MMA without surgical treatment, and group B-72 patients who were treated surgically (minimal debridment or simple wound closure) in the local hospitals before the evacuation to the MMA. The outcome was assessed on the discharge from the MMA according to the Glasgow Outcome Scale (GOS). Severe penetrating injuries had poor outcome as compared to moderate and mild injuries (p=0.001). Multilobar and bihemispheric injuries as compared to unilobar, and crossing as compared to uncrossing or tangential injuries had a poor outcome (p=0.001). Bullet injuries had a poor outcome then shrapnel injuries (p=0.016). For the treatment of the complications or additional debridement 6.5% patients from the group A and 78% from the group B were reoperated. There was no statistically significant difference regarding the final outcome of the patients from the group A comparing to the group B (p = 0.169). Severity of the injury, extensity of the cerebral lesion, the missile path, and the type of missile significantly influenced the final outcome. Minimal debridement of penetrating gunshot injuries was not a sufficient solution because it required a high rate of reoperation in the later stage.

Keywords: craniocerebral gunshot injury, penetrating injury, war injuries

INTRODUCTION

The Department of Neurosurgery of the Military Medical Academy (MMA) in Belgrade served as a major neurotrauma referral center during the civil war in the former Yugoslavia. According to the modern concept of treating craniocerebral penetrating injuries, the patients were evacuated as soon as possible from the zones of conflict to the neurosurgical hospital services capable of definite treating such injuries[1]. However, the mean evacuation time from the frontline to the MMA was longer than in the other recent wars what might influenced negatively the final outcome of the neurosurgical treatment of these patients.

We presented a retrospective review of the patients treated for craniocerebral injuries and the factors which influenced the final outcomes of the treatment of such patients.

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MATERIAL AND METHODS

In the period from September 10th 1991 to December 31st 1992, the total of 162 patients with penetrating craniocerebral war injuries were treated. There were 159 males and 3 females, in the age range 6 to 71 years(mean 29 years). Among these patients, there were 155 military personnel and 7 civilians. Seventy-two patients were surgically treated in the local hospitals before the evacuation to the Military Medical Academy (MMA). The computed tomographic (CT) evaluation was not performed preoperatively in these patients. In 9 of them the simple wound closure was only done while 63 patients underwent minimal neurosurgical debridement that included minimal craniectomy and minimal debridement of the devitalized brain tissue without extirpation of the in-driven metallic or bone fragments, and with non-water-tight dural closure. Ninety patients were referred to the MMA without any surgical treatment. The average evacuation time of these patients was 12 hours. For the group of patients that were surgically treated in the local hospitals, the average evacuation time was not calculated because some of the patients were treated several days before the referral.

On the admission to the MMA, the patients with penetrating head injuries underwent routine trauma evaluation and neurological grading with prophylaxis with three antibiotics: cefriaxone, amikacin, and metronidazole. Computed tomographic evaluation was done as soon as the vital functions were stabilized in each of the patients. CT evaluation, as a rule, preceded emergency surgery. Traditional debridement of the craniocerebral penetrating injury was performed as a standard procedure. The skin incision and the subsequent craniectomy exposing the entire dural defect until healthy dural margins were visible were performed before the dural opening and the proper brain debridement. Our strategy was to remove in-driven bone or metallic fragments, but only those that we approached during the removal of the blood clot and brain tissue debritus. Since our policy was to perform the brain sparing debridement technique, we did not search for the remote in-driven bone or missile fragments. The primary dural watertight closure was performed in all the cases operated on using either auto or allograft materials (fascia lata, temporal fascia, liodura).

The final outcome was analyzed with respect to the severity of the injury, the extensity of cerebral lesion, the missile path, the type of missile, and the data on the previous treatment. The severity of injury was measured according to the Glasgow Coma Score (GCS) so that a mild injury was considered to be in these patients with GCS 13-15, moderate 9-12, and severe 3-8[2]. The extensity of the cerebral lesion was classified as unilobar, multilobar, bihemispheric, transventricular and haemathoma with shift[3]. According to a type of missile, injuries were divided into those caused by bullets or shrapnels. According to the missile path, there were crossed, non-crossed, and tangential injuries.

The patients were divided into two groups according to the treatment that they received: Group A- 90 patients who were referred directly to the MMA, and group B- 72 patients who were treated surgically (minimal debridment or simple wound closure) in the local hospitals before the evacuation to the MMA. The outcome was assessed on the discharge from the MMA according to the Glasgow Outcome Scale (GOS)[4]. The average stay in hospital was 18 days (range: 2 - 98 days). For the statistical analysis, we used the Pearson chi-square test and the two-sided test of differences between two percentages. The differences were considered significant at $p<0.05$.

RESULTS

Penetrating craniocerebral injuries were caused by the shrapnel in 103 cases, by bullets in 50 cases, while in 9 patients the type of missile could not be assessed. Considering the severity of injury on the admission, there were 78 with mild, 48 with moderate, and 36 patients with severe injuries. The cranial penetration sites were as follows: frontal region 63, temporal 37, parietal 37, occipital 10, facial 13 and multiple sites of penetration were noted in 2 patients. There were 59 patients with unilobar, 58 with multilobar, 31 with bihemispheric, 8 with transventricular injuries, and 6 patients with hematoma with shift. Sixty-six patients presented with hemiparesis, hemiparesis with sensory or motoric dysphasia in 10, paraparesis in 4, dysphasia in 2, and amaurosis in 1 patient. Associated injuries were registered in 41 patients: extremities in 24, chest in 9, abdominal injuries in 5, extremities and chest in 1, extremities and abdomen in 1, and the extremities and neck in 1 patient. Nine patients in whom the type of missile was unknown were excluded from the rows *type of missile*

In the group A, 77 patients were operated on while 13 received nonsurgical treatment. In the group B, 51 patients were operated on while 21 were treated nonsurgically. Of 13 patients from the group A, that were treated nonsurgically in the MMA, 7 were in so poor condition on the admission to the MMA, that they died during the diagnostic procedures and the preparation for the surgery. There were 5 patients from the group A that were reoperated: 2 patients for cerebral abscess, 1 for intracerebral haematoma, and 2 underwent reoperation for the CSF fistula. Out of 51 patients in the group B who were reoperated on in the MMA, 34 underwent the traditional debridement, 13 were operated on for the removal of the large metallic and/or bone in-driven fragments, 2 due to the CSF fistula, 1 due to the cerebral abscess and 1 due to the osteomyelitis of the skull. Out of 34 patients that underwent reoperation for the traditional debridement in the MMA, 9 of them previously underwent only simple wound closure, while 25 of them were operated on performing the minimal debridement in the local hospitals. Out of the total of 72 patients that underwent either the simple wound closure or the minimal debridement in the local hospitals (group B), 51 (78%) were reoperated. Out of the total of 77 patients that underwent traditional debridement in the MMA (group A), as a primary treatment, 5 (6.5%) patients were reoperated in the later period ($p=0.001$).

In the total of 162 injured, 24 had a good outcome, 46 were moderately disabled, 61 were severely disabled while 2 patients remained in vigil coma, and 29 (17.9%) patients died. Deaths were caused by the primary cerebral injury in 23 patients, and as a consequence of the associated coincidental injuries and complications in 6. Twenty-one (26.9%) patients had a good outcome, 34 (43.6%) were moderately disabled, 22 (28.2%) were severely disabled, and 1 (1.3%) died in the group of 78 patients with a mild

injury. There were no patients who had a good outcome or moderate disability, while 10 (27.7%) were severely disabled and 24 (66.6%) died in the group of 36 patients with severe injuries. (Table 1). Twenty (33.9%) patients had a good outcome, 24 (42.4%) were moderately disabled and 1 (1.7%) died in the group of 59 patients with unilobar injury. Three (5.2%) patients had a good outcome, 16 (27.6%) were moderately disabled, and 14 (24.17%) died in the group of 58 patients with multilobar injuries. Among the 31 injured who suffered bihemispheric injuries, 12 (38.7%) died (Table 1). There were no deaths in the group of patients with tangential injuries, while the mortality was 15.4% in the patients with uncrossed penetrating injuries, and 46.4% in the patients with crossed injuries. The mortality of the injured with bullets was 32%, and with shrapnel 10.6%. The final outcome was negatively correlated to the severity of injury, extent of the cerebral lesion, crossed wounds, and bullets caused injuries. There was no statisticaly significant difference regarding the outcome between the groups A and B (p=0.169) (Table 1). The infective complications were dominant in the 21 patients with the early postoperative complications (Table 2).

Table 1. Factors affecting outcome in war penetrating craniocerebral injuries

Factors		Glasgow outcome scale					
		Good	Moderate Disability	Severe disability	Vegetative State	Dead	Pearson Chi-Square
Severity of injury	Mild	21	34	22	0	1	p = 0.001
	Moderate	3	12	29	0	4	Very
	Severe	0	0	10	2	24	significant
Extent of cerebral lesion	Unilobar	20	25	13	0	1	p = 0.001
	Multilobar	3	16	25	0	14	Very
	Bihemispheric	1	3	15	0	12	significant
	Transventricular	0	1	4	1	2	
	Haematoma/shift	0	1	4	1	0	
Form of penetration	Tangential	9	13	8	0	0	p = 0.001
	Uncrossed	15	33	39	1	16	Very
	Crossed	0	0	14	1	13	significant
Type of Missile	Shrapnel	17	36	38	1	11	p = 0.016
	Bullet	7	9	17	1	16	significant
Differ. In Management	Group A	16	22	30	1	21	p = 0.169
	Group B	8	24	31	1	8	not-signif.

Table 2. Early complications of war penetrating craniocerebral injuries

Complications	Number of patients
Superficial infection	4
Cerebral abscessus	4
Sepsis	1
Meningitis	4
Cerebrospinal fluid fistula	3
Epilepsia	4
Intracerebral hematoma	1
TOTAL	21

Out of 4 patients with the cerebral abscess, 2 had a bone in-driven fragments while 1 had metallic and bone in-driven fragments. Out of 4 patients with the early posttraumatic epilepsy, 1 had in-driven bone fragments.

DISCUSSION

The time period that passed from the injury to the definite neurosurgical treatment of the injured was from 30 hours to 8 days according to the data from the World War II [1]. In the Korean and Vietnam war the evacuation was significantly faster: average time being 2 hours[5], and in the Lebanon war, that time was 2.3 hours[3]. The evacuation time to the closest local neurosurgical unit, in our experience, was 1.5 hours[6]. The injured from the different battlefields in the former Yugoslavia have been referred to the MMA in Belgrade more or less far from the front lines. Since the MMA was relatively far from the zones of conflict, and due to other technical reasons imposed by civil war conditions, the average evacuation time was 12 hours for the injured that were referred directly to the MMA (group A). That was significantly longer time as compared to the data from the Vietnam, Korean and Lebanon wars. Early surgical treatment of penetrating craniocerebral injuries is considered important for the prevention of the development of complications and for the improvement of the final outcome[7].

However, in spite of the longer evacuation time, there was no significant difference in the mortality and complications rate in our patients as compared to the data from the Vietnam, Korean and Lebanon wars, in which the average evacuation time was significantly shorter[3,6,8,9]. The reported of this fact should not be understood as the neglect of the importance of the strategy of the prompt evacuation of all the craniocerebral injury patients to the neurosurgical services. On the contrary, it is considered as a basic principle in the treatment of the injured in a war. All the injured were evacuated after triage, including the most severely injured, who eventually died in hospitals, thus making the hospital mortality rate higher. That was the reason for Hammon[10] not to take into account those most severely injured when reported hospital mortality rate from craniocerebral war trauma. Unfortunately, due to the long evacuation time to the MMA, several patients with severe injuries died in the local hospitals, while waiting for the transport. This fact consequently decreased the overall in-hospital mortality rate in the MMA. According to our experience, surgical treatment with the minimal debridement or only simple skin closure performed in the field hospitals increased the reoperation rate, in the later stage, in the group B. It is well known that the treatment outcome of craniocerebral penetrating injuries depends mainly on the neurological GCS grading after the traumatic event and on the extensity of the cerebral lesion[3,6,10,11]. The outcome recorded in our patients was significantly determined by

the same factors too, so that the worst outcome was recorded in the patients presented with GCS 3-8, and those with multilobar or bihemispheric cerebral lesions. As far as we know, there is no a data in the literature regarding the influence of the missile path on the final outcome of a penetrating craniocerebral injuries. Aarabi at al[9] analyzed the final outcome regarding the missile path and the posttraumatic infections rate and reported that the higher rate of infections was noted in the patients with crossed injuries comparing to uncrossed and tangential injuries that accounted for the worst outcome of such injuries. High velocity bullets produce much more damage to the brain as compared to shrapnels[3,10,12]. Of the factors that influence the final outcome we found that a type of bullets had the lowest level of statistical significance.

The rate of infection in our patients was similar to the rate reported in the literature[14,15,16]. The Vietnam war authors in their reports considered the presence of the in-driven bone or grenade fragments as early postoperative complications that may cause further complications such as postoperative bleeding, epilepsy and infections. Accordingly, the reoperation for the removal of such fragments was considered reasonable[7,10,13]. In the later wars this consideration was radically changed. Levy et al[3]. did not find any complications related to in-driven fragments in the group of patients during the follow-up period of 6 years. Others[14,15,16] reported the similar observations. Thirteen of our patients underwent reoperation for a large piece of metal or bone indriven fragments.

There was an attitude that the traditional debridement of the penetrating injury including the watertight dural closure was not necessary since the same result was achieved using the minimal debridement without the watertight dural closure[14,15]. However, the comparison of the results achieved using the traditional comparing to the minimal debridement reported by Carey revealed that the traditional debridement was a better treatment option [17]. The surgical strategy employed in the MMA included the traditional debridement while, at the same time, the minimal debridement was mainly employed in the local hospitals. The fact that the patients already operated on in the local hospitals were reoperated in the MMA either for additional debridement or for the treatment of early complications, confirmed the traditional debridement as the more successful surgical strategy.

CONCLUSION

Severe penetrating injuries (GCS 3-8) had poor outcomes as compared to moderate (GCS 9-12) and mild injuries (GCS 13-15), and injuries of multiple cerebral lobes and both hemispheres as compared to unilobar, crossing injuries as compared to uncrossing or tangential injuries, as well as bullet injuries to shrapnel injuries.

Minimal debridement of penetrating gunshot injuries was not a sufficient treatment solution because, according to our experience, it required a high rate of reoperation in the later stage.

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