ORIGINAL ARTICLE

Civilian Gunshot Wounds to the Brain

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Background: Civilian gunshot wounds to the brain are relatively rare, and a much-neglected subject in Taiwan. We present our experience with 16 patients who sustained gunshot wounds to the brain, and then identify factors determining the respective outcomes.

Methods: From 1988–2002, data from 16 patients with civilian gunshot wounds to the brain, who were treated at Taichung Veterans General Hospital, were retrospectively reviewed. Historical information, clinical manifestations, and imaging findings were described. Based on Glasgow Outcome Score (GOS), patients were divided into a poor-outcome group (GOS, 1–2) and satisfactory-outcome group (GOS, 3–5) for further analysis.

Results: The overall mortality rate was 31.3% (5 of 16 patients). Thirteen patients underwent surgery, and the surgical mortality rate was 15.4% (2 of 13 patients). Of the 7 patients with a Glasgow Coma Scale (GCS) score of more than 8, all survived with satisfactory outcomes; of the 9 patients with a GCS score of less than 8, 8 had poor outcomes (5 died, and 3 were in a persistent vegetative state); $p < 0.005$ between the 2 GCS groups. In addition, the rate of satisfactory outcome was significantly higher in 7 patients with limited brain injury, as determined by computed tomography (CT) scan, than in 8 patients with extensive brain injury (86% vs 25%; $p < 0.05$).

Conclusion: GCS score on admission, and the extent of brain injury as visualized by CT scan, seem to be the 2 most significant predictors of outcome in cranio-cerebral gunshot wounds. Patients with a GCS score of more than 8, or brain lesions limited to a single lobe of the brain, may benefit from aggressive management. [*J Chin Med Assoc* 2005;68(3):126–130]

Key Words: cranio-cerebral gunshot wound, Glasgow Coma Scale, Glasgow Outcome Score

Introduction

Gunshot wounds to the brain are rare in Taiwan because laws prohibit gun possession. However, a recent escalation in crime seems to have increased the prevalence of cranio-cerebral gunshot wounds. This has led to additional challenges in neurosurgical care.

The extent of brain damage caused by a bullet is directly related to the energy released by the bullet, which can be calculated from the following formula: $E = M \times V^2/2$; where E is energy, M is bullet mass, and V is its velocity. Civilian cranio-cerebral gunshot wounds are usually inflicted by small-caliber, low-velocity bullets (< 1,200 ft/sec), which cause less destruction of brain tissue than high-velocity military bullets.[1,2] Thus, using aggressive management, more lives can be saved and more neurologic functions preserved in civilians with cranio-cerebral gunshot wounds.[3,4]

In general, a patient admitted with a multilobar gunshot injury and low Glasgow Coma Scale (GCS) score has a poor outcome. In this report, we present our experience in the treatment of cranio-cerebral gunshot injury, and indicate the relative importance to outcome of admission GCS score and computed tomography (CT)-defined extent of injury.

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Methods

Study population

Data from a total of 16 patients with civilian gunshot wounds to the brain, and who were admitted to Taichung Veterans General Hospital over a 14-year period (1988–2002), were retrospectively analyzed. Fifteen males and 1 female were included, with ages ranging from 14–68 years (mean, 30.9 years). All patients were shot by handgun: 15 were subjected to homicidal assaults; 1 suffered a self-inflicted wound. Three hemodynamically unstable patients were first managed for resuscitation. Endotracheal intubation and mechanical ventilation were performed immediately in the emergency room for 11 patients; all 16 patients had neurologic impairment (GCS score < 14). All patients had a CT scan as soon as they were hemodynamically stable, except for 1 patient who deteriorated rapidly. Three patients with a GCS score of 3 and non-reactive pupils were managed conservatively. All other cranial wounds were managed with adequate decompressive procedures or debridement to remove hematomas, surgically accessible fragments, and devitalized tissues.

Assessment of outcomes

Each patient's outcome was assessed at discharge using the Glasgow Outcome Score (GOS):[4] 1 = death; 2 = persistent vegetative state; 3 = severe disability (dependent on daily support); 4 = moderate disability (disabled but independent); 5 = good recovery. For statistical analysis, we classified patient outcomes into 2 groups: poor outcome (GOS, 1–2); and satisfactory outcome (GOS, 3–5). Based on admission GCS score, patients were also divided into 4 categories: minimal or no neurologic deficits (GCS, 14–15); significant deficits without coma (9–13); comatose but not moribund (5–8); and moribund (3–4).

Statistical analysis

Pearson's Chi-squared test was used to analyze the relationship between GCS score on admission and GOS. Fisher's exact test was used to verify the correlation between extent of brain injury and outcome.

Results

The overall in-hospital mortality rate was 31.3% (5 of 16 patients). Thirteen patients (81.3%) underwent surgery, and the surgical mortality rate was 15.4% (2 of 13 patients). Of the 11 survivors at discharge, 5 (45.5%) had a good recovery, 2 (18.2%) had moderate disability, and 1 (9.1%) had severe disability. The remaining 3 patients (27.3%) were in a persistent vegetative state.

Table 1. Glasgow Coma Scale (GCS) scores and outcomes*

GCS score	Glasgow Outcome Score					Total
	Poor outcome		Satisfactory outcome			
	1	2	3	4	5	
14–15				1	4	5
9–13				1	1	2
5–8	2	2	1			5
3–4	3	1				4
Total	5	3	1	2	5	16

*Data shown are numbers of patients.

Outcome analysis

Five patients with a GCS score of 14–15, and 2 with a GCS score of 9–13, had satisfactory outcomes. Of the 5 patients with a GCS score of 5–8, 1 had a satisfactory outcome and 4 had poor outcomes. All 4 patients with a GCS score of 3–4 had poor outcomes. A higher admission GCS score was associated with a significantly higher rate of satisfactory outcome (Pearson's χ^2-test, $p < 0.005$; Table 1).

CT scans of the brain were performed in 15 patients and demonstrated 3 non-dura-penetrating injuries, 4 single-lobe injuries, and 8 multilobar injuries, with the latter including 4 cross-mid-coronal and 4 cross-mid-sagittal injuries (Figure 1). Patients with non-dura-penetrating or single-lobe injuries were included in the limited brain-injury group, whereas patients with multilobar gunshot injuries were included in the extensive brain-injury group. Of the 7 patients with limited brain injury, 6 (85.7%) had satisfactory outcomes, and 1 was in a persistent vegetative state (GOS, 2). Among the 8 patients with extensive brain injury, 4 (50%) died, 2 (25%) were in a persistent vegetative state, and 2 (25%) had a satisfactory outcome (Table 2). Thus, there was a significant correlation between the extent of brain injury and outcome (Fisher's exact test, $p < 0.05$).

Complications

Complications in 11 survivors comprised seizure in 2 patients (18.2%), cerebrospinal fluid leakage in 1 (9.1%), and brain abscess formation in 3 (27.3%). Intracranial infection, which often delayed neurologic recovery, may have contributed to poor outcome in the 3 patients in this series who had such an outcome (GOS, 2).

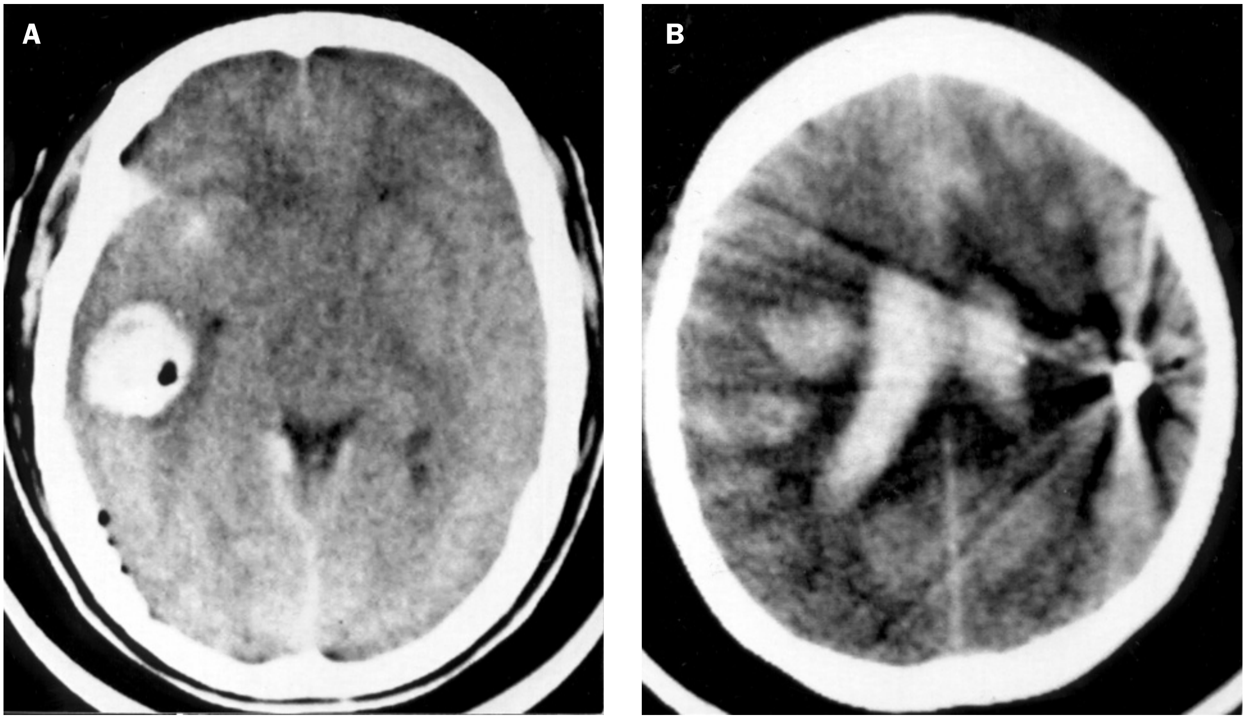

Figure 1. A computed tomography scan showing: (A) single-lobe gunshot injury; (B) cross-mid-sagittal, multilobar injury.

Discussion

Peak mortality from cranio-cerebral gunshot injuries happens at the scene or within 3 hours of injury.[5,6] Thus, victims who present with stable vital signs or reactive pupils will potentially benefit from aggressive treatment, especially when the victims have been rapidly transported to hospital. Initial resuscitation is important to prevent secondary insults, such as hypoxia, ischemia, and hypotension. In our series, 2 patients presented with shock (systolic blood pressure < 90 mmHg), and another had dyspnea due to associated chest gunshot injury. Among these 3 patients, 1 died and 2 were in a persistent vegetative state (GOS, 2).

Kennedy et al reported a mortality rate of 91.4% with a GCS score of 3–4, and 61.2% with a GCS score of 5–8, in patients with gunshot injuries to the brain.[7] Kaufman et al reviewed 11 studies and found that few of the 831 subjects with low GCS scores had a satisfactory outcome:[8] 1 had a GOS of 5; 15 had a GOS of 4; and 41 had a GOS of 3. Several studies[2,9–15] reported that GCS score was the most significant prognostic factor in cranio-cerebral gunshot wounds. Our data corroborated previous studies by demonstrating that a low GCS score correlated with poor outcome. The mortality rates in our patients with GCS scores of 3–4 and 5–8 were 75% and 40%, respectively. It is also worth noting that the GCS score might be underestimated in certain situations, such as early seizure, and drug or alcohol use; such possibilities should be excluded by taking histories from witnesses.

Table 2. Computed tomography (CT) scan findings and outcomes*

CT scan findings	Glasgow Outcome Score					Total
	Poor outcome		Satisfactory outcome			
	1	2	3	4	5	
Limited brain injury (non-penetrating/single-lobe)		1	1	1	4	7
Extensive brain injury (multilobar)	4	2		1	1	8
Total	4	3	1	2	5	15

*Data shown are numbers of patients.

A CT scan is the best diagnostic tool for patients with cranio-cerebral gunshot injuries because it provides quick and accurate information about the extent of brain injury, and the sites of hematoma and bullet fragments. CT-scan findings can be used to plan surgery, to predict outcome, and even for postoperative follow-up. Poor outcomes in patients with extensive brain injury indicated by CT scan have been documented previously,[10,13,16] and patients with extensive brain injury in our series had similarly poor outcomes: 50% of patients (4 of 8) died, and 25% (2 of 8) were in a persistent vegetative state. One patient with a unilateral, 2-lobe injury had a favorable recovery (GOS, 4), probably because injury was to the non-dominant hemisphere. The other patient with a bifrontal-lobe injury recovered fully (GOS, 5), probably because bifrontal gunshot wounds are generally far away from the brain stem, thalamus, and important vascular structures.

The overall mortality rate of 31.3% in our series was lower than that of 51–84% reported by others.[9,11,16] This might be related to the lower rate of suicidal gunshot injury (only 1 case) in our series because guns are not easily obtained by our civilians. Suicide attempts have been clearly associated with poor outcomes because of more accurate and devastating injury.[10,13,17,18] Indeed, one can assume that firing at close range and taking careful aim have a major influence on the immediate effects of the shot.

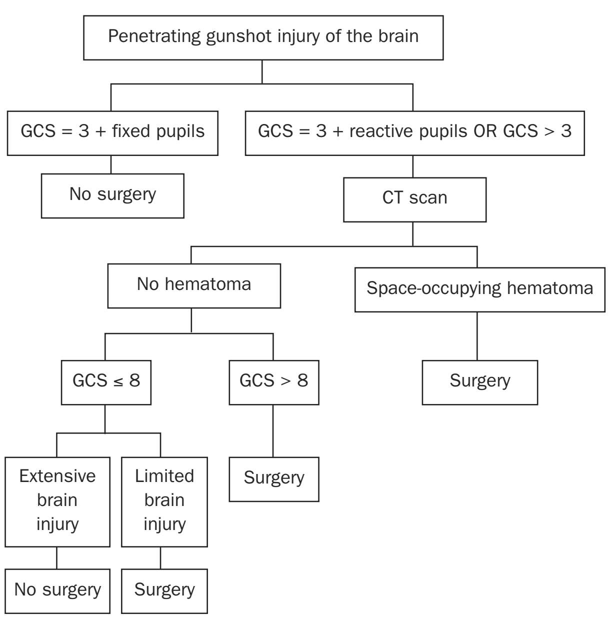

Figure 2. Therapeutic guidelines for cranio-cerebral gunshot injuries. CT = computed tomography; GCS = Glasgow Coma Scale score.

Despite several reports about cranio-cerebral gunshot injury, the question of which patients should be candidates for aggressive surgery remains controversial.[2,5,13,16] In the present series, our surgical criteria were based on the reactive pupil reflex and hemodynamic stability. Surgical procedures mainly included irrigation, debridement of devitalized tissues, and removal of space-occupying hematoma, in-driven bone, and accessible bullet fragments. Exploration of deep-seated bullet fragments was never done. In the only prospective study in the literature, Grahm et al, who analyzed the results of aggressive surgical treatment in 100 patients, found that none of the patients with a GCS score of 3–5 had a good recovery.[9] Based on the protocols proposed by Grahm et al[9] and Stone et al,[4] and on our experience, we recommend a modified algorithm (Figure 2) as a therapeutic guideline for the management of cranio-cerebral gunshot injuries.

In conclusion, cranio-cerebral gunshot wounds are a high-mortality emergency in the neurosurgical field. Admission GCS score is the most powerful prognostic indicator. The extent of brain injury, as visualized on CT scan, is also an important prognostic factor. Patients with a GCS score of more than 8, or lesions limited to a single lobe of the brain, have improved outcomes with aggressive treatment. Surgical treatment for patients with low admission GCS scores and extensive brain injury is not recommended.

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