Research Article

Clinical Outcomes and Prognostic Factors in Cranio-Cerebral Gunshot Wounds

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Abstract

Cranio-cerebral wounds by gunshots (CCGW) represent most severe form of missile injury to the brain, often leading to devastating outcomes. In this retrospective analysis, we examined and contrasted the clinical outcomes of ten cases of CCGW, aiming to identify predictive factors and treatment strategies associated with patient prognosis. Ten individuals (8 male, 2 female), aged 22 to 65, diagnosed with CCGW between 2018 and 2019 due to unintentional discharge or military combat, were included in the study. Initial assessment upon admission utilized the Glasgow Coma Scale (GCS), with subsequent surgical interventions following comprehensive diagnostic evaluations including imaging modalities (X-ray skull, brain CT, Angio-CT), and assessment of neurosurgical and hemodynamically, and mental status. Our findings revealed predictive factors indicative of poor outcomes, including over age, poor transportation due to the lack of vehicles and damage roads, low glas Gow coma scale in admission, multiple brain damage observed on CT scans, and trajectories inflicted by gun bullets fired with high-speed velocity with nearby to the victims, often resulting in hemispheric, multilabor injuries with brain stem and ventricular involvement. Despite aggressive critical care interventions, including surgical treatments, mortality rates remained high, particularly in cases presenting with significant ventricular damage, brain injuries, and lateral plane high-speed bullet trajectories. However, patients with higher admission CGS scores showed improved survival rates. In conclusion, CCGW represents the most severe form of missile-induced brain injury, characterized by high mortality and morbidity rates. While aggressive critical care interventions combined with early management and meticulous neurosurgical approaches have contributed to reduced mortality and morbidity, primary prevention remains paramount in mitigating these devastating injuries.

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INTRODUCTION

Neurosurgeons are seeing an increasing number of craniocerebral gunshot injuries (CGI) in civilian and urban settings; these injuries were formerly mostly seen and treated in military settings, but are now more common in developing nations. Penetrating brain injury has a worse prognosis than closed head trauma, but being less common (1). With documented survival rates ranging from 7% to 15%, CGI injuries are the deadliest of any firearm injuries (2). Approximately 90% of victims pass away before receiving medical attention at a hospital, and of those who do make it there, 50% more pass away in the emergency department (3,4). Peak CGI mortality typically occurs near the site of the injury or within the first three hours following the damage (4,5). Thus, in any country experiencing civil armed conflict, the treatment of gunshot (missile) wounds to the brain (craniocerebral) which result of bullets, shotguns, blasts, grenade explosions, and mines is standard practice at neurosurgical centers. Given that patient epidemiology is a complex phenomenon impacted by social, psychological, and cultural factors, there is a possibility that the features of CGI patients vary significantly between nations.

There are numerous lessons to be discovered. The review that is now underway looks at contemporary DAI lesions, high speed bullets, brain injury, axonal injury, and cerebral gunshot wounds When high-speed bullets cross in multiple (2–6) regions of the brain, they cause catastrophic injuries to brain including impact injury, perforating, and penetrating and acceleration deceleration (1) (2) (3). These injuries are the most severe and frequently fatal kind of missile damage to the head.

MATERIALS AND METHODS

Ten patients (8 men, 2 women) presenting with Cerebral Gunshot Wounds (CCGW) were admitted to the neurosurgery department of Nangarhar University Teaching Hospital and Nangarhar Regional Hospital in the eastern region of Afghanistan between 2018 and 2019, following incidents of military conflict or unintentional firing. Upon admission, all patients underwent initial assessment and resuscitation utilizing the Glasgow Coma Scale (GCS). Subsequently, patients with critical conditions were airlifted for further management. Four patients presented with a Glasgow Coma Scale (GCS) score of nine, ten, or three, while the remaining six patients had a GCS score of three. Radiological assessments, including head Xray and head CT scans in both brain and bone windows, revealed findings such as pneumocephalus, various types of fractures, and presence of complete or fragmented missiles with associated bone defects. Cerebral CT scans delineated the extent of penetrating injuries throughout the brain.

Brain angiography was performed in four cases where the trajectory of the missile intersected with the middle cerebral artery, aiming to identify and address potential complications such as pseudoaneurysm or Dural sinus tear. Furthermore, cerebral MRI and Single-Photon Emission Computed Tomography (SPECT) were conducted three weeks post-injury in two survivors exhibiting neuronal impairments related to cavitation, seizures, ischemia, and Diffuse Axonal Injury (DAI) lesions. Baseline laboratory tests, along with assessments of neurological, hemodynamic, and coagulability statuses, were conducted for each patient. In cases where intraparenchymal cavities were generated following blood clot removal, intracranial pressure monitoring was implemented. Additional treatments included compatible blood transfusion, therapy for coagulopathy and shock, administration of antibiotics, and anticonvulsant therapy.

RESULTS

Surgical interventions for all patients included primary wound closure, cleaning and debriting of skin, death hairs, and necrotic tissues, as well as hematoma removal, hemostasis, and duraplasty. Additionally, patients underwent surgical procedures for hemostasis, duraplasty, debriding of skin, hairs, and necrotic tissues, and removal of hematomas, visible missiles, and bone pieces. No attempts were made to pursue incompletely reachable bone or missile fragments to prevent further trauma to the injured brain. Of the total projectiles, five bullets remained intact, measuring 25 and 30 mm in length, 8 and 12 mm in diameter, and weighing 10 and 16 g. The remaining three bullets were distorted, mushroomed, or fractured. All patients received initial treatment consisting of mannitol, anticonvulsants, and broad-spectrum antibiotics. Unfortunately, 3 victims with temporal and temporo-occipital injuries succumbed within the first forty eight hours post-surgery despite receiving early surgical procedures due to respiratory arrest. Persistent therapy-resistant brain enlargement with midline shift was observed in some cases. 2 victimis with hemiparesis underwent to rehabilitation stage, resulting in improved health after a year. However, they remained unable to resume their pre-injury activities and continued anticonvulsant therapy without further complications. Forensic neuropathologists reconstructed the brain injuries of the six deceased patients using macroscopic findings related to entrance and exit wounds, missile tracks, and secondary changes associated with CT reconstruction. Microscopic assessments of cellular and axonal degeneration surrounding the permanent tracks corresponding to temporary holes were conducted in six cases. Trajectories of speedy bullets, particularly temporal and temporo-occipital, were identified as the most hazardous. An illustrative case study is provided for P.C., a 25-year-old who sustained wounds of guns to the brain and brain on January 1, 2017, in Kunnar province. Despite receiving immediate medical attention upon admission to Nangarhar Regional Hospital, the patient succumbed to his injuries on the same day**.**

DISCUSSION

The most severe injuries in humans, known as cranio-cerebral gunshot wounds (CCGW), involve the structures of the central nervous system and are a serious public health problem (1), (2), and (6). CCGW can be caused by: penetrating projectiles, which enter the skull but do not exit it; these can be produced by low speed projectiles such as air rifles; perforating projectiles, which completely pass through the head, leaving both inner and outer holes in wounds; these can be produced by high-mass and velocity metal jacket bullets fired from military weapons; or by guns fired from very close range, such as in aggression or suicide attempts (2) (3) (6-12) (14).Roughly 2 million traumatic brain injuries happen annually, and trauma-related deaths account for 50% of all trauma-related deaths. Three-quarters of these deaths are related to gunshot wounds to the head (1) (4).

Every year, at quiet times, there are 24000 firearm-related fatalities and injuries, making it the fourth most common cause of death in the US and the top cause for those between the ages of one and forty-four. This level of loss is comparable to all American casualties throughout the Vietnam War (4); a bullet wound to the head increased the patient's risk of death by 35 times.

Over millennia, various historical documents have depicted instances of cranio-cerebral head traumas, such as depressed skull fractures, dating back to 1700 BC in Egyptian papyrus. Treatment methods described in these records included applying grease to scalp wounds and allowing intracranial drainage. Hippocrates, around 460-357 BC, utilized trephination to address skull fractures. Galen, in the years 130-210 AD, noted a relationship in the side of injury and motor loss. However, until the mid-19th century, cranio-cerebral injuries were considered largely incurable, with high mortality rates, reaching around 75% in Homer's time (circa 700 BC), and declining only slightly to 71.5% in the American Civil War. Major advancements in the management of cranio-cerebral injuries emerged around 1750, notably with the contributions of figures like Louis Pasteur, Robert Koch, and Joseph Lister in bacteriology and asepsis. These developments significantly reduced the incidence of both local and general infections, thus decreasing mortality rates associated with such injuries. Harvey Cushing's measures during the First World War further advanced the treatment of cranio-cerebral injuries. His approach emphasized aggressive debridement of devitalized tissue, removal of metal and bone fragments along the missile track, exploration of the intradural space, and meticulous closure of dural lacerations. These interventions aimed to mitigate infections, abscess formation, and reduce mortality rates from cranio-cerebral injuries from 56% to 28%.

Low-speed shrapnel wounds, characterized by significant tissue loss, previously carried a death rate of 14% before the discovery of antibiotics, which decreased to 9.7% during the Vietnam War (1-3) (7–10). However, in nations like Iraq and Yemen, where firearms are prevalent among civilians for various purposes such as entertainment, defense, and social conflicts, cranio-cerebral gunshot wounds (CCGW) (1-3) have transitioned from being predominantly military-related to civilian occurrences (8) (11) (12). Interestingly, military CCGWs tend to have a higher fatality rate, primarily due to variations in wound ballistics. In recent military history, despite advancements like CT scans, statistics show that 26% of conflicts involved bullets, 32% utilized shrapnel, and 10.6% were attributed to other causes. The mechanism of injury in CCGW involves the bullet causing transient cavitation, radial tissue displacement, shearing, compression, and stretching of cerebral tissue as it traverses the skull. (15).

The impact of projectiles on the brain can range from isolated soft tissue injuries to "explosive" injuries such as comminuted skull fractures or bullet fragments causing brain laceration (1) (3) (11), as well as extensive destruction of neuronal cell membranes. These effects are dependent on the projectile's physical characteristics and ballistics (12) (15–18). An expanded area of broken tissue is being produced by the amplified effects of transient cavitation; elevated intracranial pressure is manifested morphologically by cortical contusion zones; indirect fractures of the skull and perivascular bleeding that occurs outside of the tract. Along the bullet's passage, there are varying degrees of brain cavitation, which are often several times greater than the bullet's diameter (1) (3) (5) (17) (18).

After CCGW frequently seen effects are: neurodeficits, brain swelling with ICP rise, CSF leaks with severe infections, caroticocavernous fistulas, pseudoaneurysms correlated with morbidity and mortality (3) (9-12). Many CCGWs are incompatible with life, but Patients with moderate injuries are more likely to receive aggressive treatment for subsequent mechanisms of harm and to be resuscitated. Regarding what constitutes effective treatment for CCGW, neurosurgeons now differ greatly (3) (4) (10).

In 1970, Raimondi and Samuelson observed variations in wound ballistics and proposed a categorization system predicated on preliminary neurologic evaluation. Kaufman (14) acknowledges the surgical debridement performed, the use of ICP monitoring, and several medical therapy. Arendall and Meirowsky (1983) demonstrated that quick and radical debridement can lower the high mortality associated with penetrating wound of air sinuses. According to Helling et al. (1992), earlier surgical intervention seems to improve survival. Acute or delayed CSF leakage is strongly associated with cerebral infection (9) (12) according to Gonul 1997 and Singh 2003.as much as the efficacy of the treatment (3) (13) Treatment for CCGW involved four stages: extreme debridement to restore anatomical structures, ICP monitoring, infection avoidance, preservation of nervous tissue, and rapid life-saving medicinal interventions (10).

The efficacy of treatments such as steroids, hypothermia, hyperventilation, and the duration of antiepileptic and antibacterial medications remains a topic of debate (9) (12). Several factors associated with morbidity and mortality (1-6) (8-15) serve as predictors of poor outcomes in cranio-cerebral gunshot wounds (CCGW), including advanced age, very close-range firing, admission Glasgow Coma Scale (CGS) scores of 3 and 4 (indicating rare and high mortality), bilateral fixed dilated pupils with open cornea, delayed and inadequate transportation, apnea upon admission, associated injuries to the chest, abdomen, and major vessels leading to significant bleeding, hemodynamic instability (hypotension), abnormal coagulation states, diffuse brain damage evident on CT scans, as well as specific patterns of missile trajectory such as hemispheric, bitentorial, and multilobar with lateral inclinations exceeding midline trajectories, brain stem and ventricular injuries, ventricular and subarachnoid hemorrhages, vasospasm, hematomas larger than 15 ml, signs of herniation, mass effect, and midline shift.

Retained missiles, bone and hair intraparenchymal fragments with DAI lesions, CNS infection, pneumocephalus, and neuronal injury related to cavitation and convulsions all have less detrimental effects (3) (9) (10) (13).

CONCLUSION

The mortality and morbidity is related to early admission, age, early diagnosis and early primary sruvy, and also to prevent secondary pathologies. And it is reduced by aggressive intensive care management in conjunction with early management using a less aggressive, modern neurosurgical technique, when appropriate, but they are still far too high. Primary prevention of gunshot wounds to the head and brain is still crucial, and the patient needs to be continuously watched for any potential sequelae. Given the rise of firearms and firearm-related violence in our society, it is the responsibility of all health care providers to talk with patients about these issues and provide necessary intervention.

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