Intracranial gunshot wound

Intracranial gunshot wound (GSW) injuries are one of the most deadly traumas. Each year in the United States, there are an estimated 70,000 victims of GSWs resulting in 30,000 deaths [1].

The high morbidity and mortality of gunshot injuries to the head impose a staggering burden on hospitals, families, court systems, and society [2].

Intracranial GSWs came to national and international attention when American Congresswoman Gabrielle Giffords was shot in the head in an assassination attempt on January 8, 2011. Her dramatic and successful recovery after neurosurgical intervention is a case study in the successful management of GSWs, highlighting the need for evidence-based treatment algorithms to decrease the morbidity and mortality of these injuries.

Epidemiology

35 % of deaths from brain injury in < 45 years old.

Two Third die et the scene.

Death in > 90 % of victims [3].

The prevalence and characteristics of traumatic brain injury (TBI) secondary to GSWs is strikingly variable in societies and reflects both the global and local scenery of violence. Since every gun/projectile combination is associated with a unique pattern of injury, war injuries differ significantly from civilian GSWs [4] [5].

Civilian GSWs are most commonly inflicted by small-caliber (0.22–0.38), low-velocity (less than 304.8 m/s) projectiles, delivered over a range of less than 50 m. These ballistic characteristics are important because the total kinetic energy (KE) imparted to the cranium and brain from the projectile can be estimated from KE = ½mv2 with m and v equal to the mass and velocity of the bullet, respectively. Moreover, GSWs with smaller, lower velocity projectiles cause less damage than that seen with high-velocity projectiles used in warfare [6].

Primary injury

Primary injury from GSWH results from a number of factors including:

1. injury to soft tissue

a) direct scalp and/or facial injuries

b) soft tissue and bacteria may be dragged intracranially, the devitalized tissue may also then support growth of the bacteria

c) pressure waves of gas combustion may cause injury if the weapon is close

2. comminuted fracture of bone: may injure subjacent vascular and/or cortical tissue (depressed skull fracture). May act as secondary missiles

3. cerebral injuries from missile

a) direct injury to brain tissue in path of bullet, exacerbated by

● fragmentation of bullet

● ricochet off bone

● deviations of the bullet from a straight path as it travels: tumbling (forward rotation – pitch), yaw (rotation about vertical axis), rotation (spin), nutation (similar to precession or wobble)

● deformation of bullet at impact: e.g. mushrooming

b) injury to tissue by shock waves, cavitation

4. coup + contrecoup injury from missile impact on head (may cause injuries distant from bullet path)

Because of the complexities of ballistics (some of which are described above) there is often more damage distally than at the entry site even though the bullet slows (losing kinetic energy).

Extent of primary injury is related to impact velocity:

● impact velocity > 100 m/s: causes explosive intracranial injury that is uniformly fatal (NB: impact velocity is less than muzzle velocity)

● non-bullet missiles (e.g. grenade fragments) are considered low velocity

● low muzzle velocity bullets (≈ < 250 m/s): as with most handguns. Tissue injury is caused primarily by laceration and maceration along a path slightly wider than missile diameter

● high muzzle velocity bullets (≈ 600–750 m/s): from military weapons and hunting rifles. Causes additional damage by shock waves and temporary cavitation (tissue pushed away from the missile causes a conical cavity of injury that may exceed bullet diameter many-fold, and causes low-pressure region which may draw surface debris into the wound)

Intracranial arterial injury

The risk factors for an intracranial arterial injury on univariate analysis were an entry wound over the frontobasal-temporal regions, a bihemispheric wound trajectory, a wound trajectory in proximity to the circle of Willis (COW), a subarachnoid hemorrhage (SAH), a higher SAH score, an intraventricular hemorrhage (IVH), and a higher IVH score. A trajectory in proximity to the COW was the best predictor of injury (OR 6.8 and p = 0.005 for all penetrating brain injuries [PBIs]; OR 13.3 and p = 0.001 for gunshot wounds [GSWs]). Significant quantitative variables were higher SAH and IVH scores. An SAH score of 3 (area under the ROC curve [AUC] for all PBIs 0.72; AUC for GSWs 0.71) and an IVH score of 3 (AUC for all PBIs 0.65; AUC for GSWs 0.65) could be used as threshold values to suggest an arterial injury. The risk factors identified may help radiologists suggest the possibility of arterial injury and prioritize neurointerventional consultation and potential DSA studies [7)].

Diagnosis

The routine use of computed tomography (CT) scans during trauma evaluation for patients with GSWs has had a significant impact on management. CT scans provide a quick, noninvasive method of assessing the location and extent of intracranial injury. Numerous studies have attempted to correlate the location of intracranial injury with outcome. The most cited prognostic factors with regard to CT findings are the presence of intracranial hematomas, ventricular injury, posterior fossa involvement, and multi lobar injury [8] [9] [10] [11].

Outcome

Gunshot wounds (GSWs) cause high morbidity and mortality related to penetrating brain injury

Due to advances in surgical techniques and critical care inpatient management, there has been a marked reduction in mortality and morbidity from patients admitted with TBI over the last 30 years [12].However, the postoperative mortality rates for GSWs remain well above 20% [13]. Due to a lack of definitive prospective studies, there are no high-grade recommendations for the management of these patients.

Recent research has focused on developing preoperative predictors of survival and functional outcome in patients with GSWs. Most studies use the admission Glasgow Coma Scale (GCS) score as a valuable prognosticator of outcome. Clark and colleagues reported death in all patients with a GCS score of 3 and questioned the value of any surgical intervention in these cases [14].Other studies have recommended aggressive management for patients with arrival GCS score > 8 due to high mortality despite surgery in patients with GCS score < 8 [15] [16].

Also, patients with fixed and dilated pupils have higher mortality rates despite surgery when compared with patients with active papillary reflexes [17] [18] [19] [20].

Residual neurobehavioral sequelae in survivors were present in all cases. Defects in long term memory for new information were the most common sequelae, whereas the persistence of linguistic and visuospatial deficits was related to the hemispheric lateralization of injury. In comparison with the outcome reported for patients with closed head injuries who had similar Glasgow coma scale scores, the patients exhibited more severe impairment due to significant focal brain injuries and less evidence of diffuse damage [21].

Age, pupils, GCS score, and bullet trajectory on CT scan can be used to determine likelihood of survival and good functional outcome. Gressot et al advocate assessing patients based on these parameters rather than pronouncing a poor prognosis and withholding aggressive resuscitation based upon low GCS score alone [22].

Case series

DeCuypere et al conducted a retrospective review of penetrating, isolated GSWs sustained in children whose ages ranged from birth to 18 years and who were treated at 2 major metropolitan Level 1 trauma centers from 1996 through 2013. Several standard clinical, laboratory, and radiological factors were analyzed for their ability to predict death in these patients. The authors then applied the St. Louis Scale for Pediatric Gunshot Wounds to the Head, a scoring algorithm that was designed to provide rapid prognostic information for emergency management decisions. The scale's sensitivity, specificity, and positive and negative predictability were determined, with death as the primary outcome.

Seventy-one children (57 male, 14 female) had a mean age of 14 years (range 19 months to 18 years). Overall mortality among these children was 47.9%, with 81% of survivors attaining a favorable clinical outcome (Glasgow Outcome Scale score ≥ 4). A number of predictors of mortality were identified (all $p < 0.05$): 1) bilateral fixed pupils; 2) deep nuclear injury; 3) transventricular projectile trajectory; 4) bihemispheric injury; 5) injury to ≥ 3 lobes; 6) systolic blood pressure < 100 mm Hg; 7) anemia (hematocrit < 30%); 8) Glasgow Coma Scale score ≤ 5; and 9) a blood base deficit < -5 mEq/L. Patient age, when converted to a categorical variable (0-9 or 10-18 years), was not predictive. Based on data from the 71 patients in this study, the positive predictive value of the St. Louis scale in predicting death (score ≥ 5) was 78%.

This series of pediatric cranial GSWs underscores the importance of the initial clinical exam and CT studies along with adequate resuscitation to make the appropriate management decision(s). Based on our population, the St. Louis Scale seems to be more useful as a predictor of who will survive than who will succumb to their injury [23].

Case reports

A 23-year-old Ukrainian male soldier was admitted to a regional hospital with a severe perforating craniocerebral wound in a comatose state (Glasgow Coma Scale score, 5). Following brain helical computed tomography, the patient underwent primary treatment of the cerebral wound with primary duraplasty and inflow/outflow drainage. After 18 days of treatment in the intensive care unit, he was transferred to a military hospital for further rehabilitation. This report details a unusual case of successful treatment of a perforating diametric craniocerebral gunshot wound [24].

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