Penetrating Cranio-Cerebral Injuries

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SUMMARY: The modern soldier, as with his predecessors, remains at risk from penetrating cranio-cerebral injury. The subject is briefly reviewed and the modern approach outlined in a military context.

Introduction
In the military setting, penetrating cranio-cerebral injuries (PCCI) are often assumed to be fatal warranting a PI expectant classification. Similar civilian injuries although often appearing less dramatic can prove equally as devastating. Immediate post-traumatic prognosis has been improved by enhanced head protection, better anatomical knowledge, antibiotics and antisepsis, improved diagnostic facilities and rapid casualty evacuation. At the same time has come a realisation that the conservative treatment option for these injuries may have more to offer than was previously thought.

Historical Perspective
Since wars began, penetrating head injury has been the bane of medical support services. The first record of PCCI goes back to 1700 BC(I). Present treatment concepts were developed under operational conditions by the French during the Napoleonic wars and by the Americans in their Civil War(2). Harvey Cushing, from his experiences as a volunteer with the British Forces in the First World War, popularised the concept of aggressive triage and early extensive surgical debridement(3,4). With selection, he was able to demonstrate a reduction in mortality from 58% to 28%(5). Thorough scalp, skull and cortical debridement with irrigation and suction was followed by careful haemostasis using muscle patches and a watertight dural closure(5).

Respect for Cushing's reputation led to acceptance of this policy for many years whereby there would be aggressive debridement, extra-and intracranially, with location and removal of all bone and metal fragments, either at the initial or delayed surgery, followed by the meticulous closure of the dura and scalp (6-23). Vietnam experience, however, revealed that this can lead to a more severe degree of neurological deficit(24).

The introduction of CT scanning enabled accurate intracranial location of fragments thus allowing far more detailed planning of any surgery. This allows the surgeon to identify and remove only those fragments which are easily accessible(25-28). This conservative approach has evolved with optimum preservation of function being the goal rather than complete clearance of all foreign material(26-29).

Civilian PCCIs are often the result of weapons such as knives and hand guns that have a low velocity compared with military weaponry(29).

A projectile imparts to a target its kinetic energy, which is a function of its velocity and mass. Brain injury is produced by the energy of the particle which may cause skull fracture or penetration. In penetrating the head, energy dissipates causing extensive fracturing of the skull and brain destruction both local and distant. The fixed nature of the skull volume means that any projectile with energy to impart will cause an acute increase in intracranial pressure. With a high velocity missile, cavitation occurs causing further brain injury.

The projectile can pass through the skull and brain and then exit, or it can merely glance the skull causing a minor head injury. A spectrum of damage between these two extremes is possible.

Most victims with gunshot wounds to the head die at the scene (30,31). In one series of 314 patients with gunshot wounds to the head, 79% died at the scene and a further 13% died within 3 hours of the injury. There were no survivors admitted with a Glasgow Coma Score (GCS) of 5 or less, with or without operation. Negative prognostic factors were advanced age, extensive brain injury, ventricular injury and severe impairment of consciousness (29).

Self inflicted injuries have an even higher mortality of 95% (29). It is suggested that this is because there is a very short distance for the projectile to travel and good accuracy resulting in maximum available energy at the target.

Recent Experience
Adherence to Cushing's aggressive method was supported by the reality of intracranial infection caused by retained foreign material in the pre-antibiotic era. Removal was therefore paramount for survival. The introduction of antibiotics altered the balance.

Three to seventeen per cent of all PCCI develop infection (7,32). The mortality with infection exceeds 50% with seizures in 50% of survivors (32). Infection usually develops within 1-5 weeks of injury (18,32). Late sepsis also is well recognised, so long term follow up of patients, with a low threshold for repeat CT scans, may be needed.
Of 600 missile injuries to the brain reported from the Lebanese conflict, 30 developed intracranial infection (33). This occurred in 21% of those with, and 1.8% of those without, retained fragments. However, only 4% of those with retained fragments who developed infection had no wound dehiscence or CSF fistula. Infections developed in 84.6% of those with retained bone fragments and wound dehiscence.

From this study the risk factors for infection were an extensive dirty wound, a missile tract passing through an air sinus into brain, coma, incomplete debridement, failed dural closure, wound dehiscence and CSF fistula.

The Gulf War was the last major conflict which involved large numbers of Service personnel. During this war, 20 cases of penetrating cranio-cerebral injury, out of 38 head injuries due to the hostilities, were admitted to the Riyadh Armed Forces Hospital (17). Chaudri et al describe their management as front line surgery to debride the wound with craniectomy and removal of bone or pieces of metal visible to the naked eye at inspection of the wound. Their series all then had CT scans on arrival at the Riyadh Armed Forces Hospital. All had intravenous antibiotics and tetanus booster and only one developed a cerebral abscess. Overall, the outcome was good, with 18 of the 20 having Glasgow Outcome Scores of 4 or more (17). This series of conservatively managed patients had a good outcome with a less than expected incidence of infection. The organisms are varied, but there is a correlation between the organism cultured from a dehisced scalp wound and the intracranial organism (33). A similar association was found in Vietnam (34).

Broad spectrum antibiotic cover is advised using maximal doses as for meningitis pending culture and sensitivity of the organism.

Discussion
The victim of penetrating cranio-cerebral injury requires meticulous care from injury to final discharge.

In battle, care starts with the Buddy system involving care of the airway, breathing, circulation, treatment of the wounds, and commencement of fluid resuscitation by the platoon or section medical assistant (medic). Further care requires removal to the company aid post (CAP), where the company medic should continue life support and arrange evacuation as a P1 to the Regimental Aid Post (RAP).

Arrival at the RAP allows the Regimental Medical Officer (RMO) to make a formal assessment of the casualty and triage accordingly. Assessing the GCS as part of the trauma assessment helps with the decision about evacuation. A GCS of 3 and fixed dilated pupils means they are effectively dead. A GCS of 10 or more should be evacuated P1. A casualty with a score less than 10 but more than 3 is not as clear cut in his management. A casualty with a GCS between 4 and 9 should be treated expectantly with frequent reassessment of his score; if the status improves to higher than 10 then P1 evacuation should be requested but if there is deterioration then death is almost certain. The severity of other injuries, the presence of adverse prognostic factors, the pressure of other casualties and of course, the phase of battle should be carefully considered in each case. High dose antibiotics and tetanus booster should be given at the RAP.

In modern war and in the ever increasing humanitarian activities, many RAPs will see civilian injuries. It should therefore be remembered that children do not respond as little adults with neuro trauma and all should be transferred P1, unless obviously dead, to the nearest neurosurgeon if the situation allows.

Evacuation from the RAP should be to a forward surgical team with neurosurgical expertise as soon as possible. Ideally any casualty with a head injury would obviously be best served by seeing a neurosurgeon for triage as early as possible in the evacuation chain.

Mobile CT scanners enable neuro surgical and maxillofacial teams dealing with head injured casualties to scan at the earliest opportunity aiding both triage and treatment. Conservative management achieves satisfactory results with minimal exacerbation of neurological injury but the basic principles of wound debridement should not be forgotten. It must however be tempered so as not to increase the risk of neurological deficit. Careful watch for abscess development must be part of the rehabilitation regimen.

Conclusion
Despite modern tactics, equipment and head protection, today’s soldier is still at risk from penetrating head injury although advances in treatment have improved survival. A soldier today, suffering injury in the front line, can expect modern, efficient treatment in close proximity to where he falls, thus increasing his chance of survival.

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