Self-inflicted submental and transoral gunshot wounds that produce nonfatal brain injuries: management and prognosis

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Object. Penetrating brain injuries caused by self-inflicted gunshot wounds are very often fatal and survivors suffer serious disabilities. Recognition of a possibly more favorable prognosis for a specific type of injury, the submental or transoral handgun or low-energy rifle wound, prompted the authors to review their experience with patients who had attempted suicide in this manner.

Methods. The records of 11 consecutive patients seen over a 10-year period (1992–2001) were retrospectively reviewed. Handguns were used by eight patients and .22 caliber rifles by the others. The patients presented with predominantly unilateral frontal brain injuries that required urgent attention. One elderly patient who had made an advance directive concerning care died. All other patients underwent craniotomy and repair of associated ophthalmological and maxillofacial injuries. Follow-up review ranged from 9 months to 3 years, during which time there were no repeated suicide attempts. All but one patient expressed satisfaction with their appearance and returned to a self-sufficient lifestyle.

Conclusions. Self-inflicted submental and transoral handgun and low-energy rifle wounds may produce serious but survivable brain injuries if the path of the bullet is limited to the frontal area. Early aggressive management of brain, dural, and craniomaxillofacial injuries should return the patient to a highly functional neurological status and restore an acceptable outward appearance. Outcomes, therefore, appear to be much better for these patients than for most patients with a penetrating brain injury due to a self-inflicted gunshot wound.

Key Words • gunshot wound • brain injury • pericranial flap • skull base reconstruction • cranial bone graft • suicide

A suicide-related gunshot wound created by placing the muzzle of the weapon below the chin or in the mouth is intended to produce a fatal intracranial injury. Failed attempts have been described in numerous reports, all of which have attributed survival to poor aim, which directs the missile track anteriorly and laterally away from the brain. With a handgun this diversion occurs when an involuntary recoil or flinch extends the head just as the trigger is pulled. With a long-barreled rifle or shotgun, the average-sized person often needs to hyperextend the neck and turn the head away from the hand that is reaching for the trigger. The bullet or blast thus exits through the lower two thirds of the face without entering the cranial cavity. Survival when the missile track does follow the intended path through the skull base into the brain has not been previously described. We, therefore, present our experience with patients who arrived alive in our emergency department with brain injuries caused by self-inflicted submental or transoral gunshot wounds.

Clinical Material and Methods

The records of 11 consecutive patients, seen over a 10-year period (1992–2001), were retrospectively reviewed. All patients had been stabilized by paramedics at the scene of the shooting and transported to Harborview Medical Center, where they were examined and resuscitated in the emergency department according to Advanced Trauma Life Support (ATLS) guidelines. Each patient was then examined by the neurosurgery, ophthalmology, and otolaryngology services, and CT scans of the head and craniomaxillofacial skeleton were obtained. For scans of the head, 5-mm axial sections were taken at 7-mm intervals for brain, bone, and blood imaging. For scans of the craniomaxillofacial skeleton, 3-mm axial and coronal sections were taken for bone and soft-tissue imaging. If the patient could not be positioned for direct coronal scanning, coronal reformations were generated from contiguous 1-mm axial sections.

One patient, a 76-year-old woman whose living will was made available by the family after completion of CT scanning, received supportive care only and died 13 hours after admission. The other 10 patients underwent frontal craniotomy for evacuation of localized blood, debridement of devitalized brain tissue, removal of bullet and bone fragments deemed safely accessible, and repair of the dura mater. Associated ophthalmological and craniomaxillofacial injuries were addressed in each patient after completion of the neurosurgical procedure. Follow-up periods ranged from 9 months to 3 years with a mean of 22 months.

Results

Summaries for each patient are presented in Table 1. All patients were caucasian and all but three were male. The
The mean age was 29.4 years (range 9–76 years). Eight patients used a handgun (.22, .25, .38, 9-mm, or .45 caliber) and three used a rifle (.22 caliber). The entrance wound was located in the submental area in five patients and in the mouth in six patients. An exit wound through the skin of the forehead was present in only four patients, two of whom had used a .38 handgun, one a 9-mm handgun, and one a .45 handgun. A large amount of brain tissue was visible as it herniated through the wound caused by the .45 handgun. All but one of the other patients suffered a skull fracture at the site where the bullet struck the inner surface of the frontal bone. In four of these patients bone and bullet fragments were palpable beneath the intact skin of the forehead or scalp.

Two patients (Cases 10 and 11) were found at the scene of the shooting to be hypotensive and unresponsive with on-site evidence of massive blood loss. In both patients the paramedics performed orotracheal intubation. The entrance wound was located in the submental area in five patients and in the mouth in six patients. An exit wound through the skin of the forehead was present in only four patients, two of whom had used a .38 handgun, one a 9-mm handgun, and one a .45 handgun. A large amount of brain tissue was visible as it herniated through the wound caused by the .45 handgun. All but one of the other patients suffered a skull fracture at the site where the bullet struck the inner surface of the frontal bone. In four of these patients bone and bullet fragments were palpable beneath the intact skin of the forehead or scalp.

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Unilateral ocular injuries were identified in six patients, two (one whose injury was caused by a .22 handgun and one whose injury was caused by a .22 rifle) of whom underwent canthotomy with cantholysis in the emergency department to relieve increased intraocular pressure caused by retrobulbar hemorrhage. Visual acuity was recorded as 20/20 in one of these patients following craniotomy, but the other patient had no light perception in the involved eye on the 1st postoperative day. An ipsilateral afferent pupillary defect had also been noted preoperatively in this patient, and a regimen of high-dose intravenous methylprednisolone had been started for a presumed traumatic optic neuropathy. Visual acuity improved to 20/200 after 48 hours of therapy. The patient who died without surgical intervention (Case 11, injury caused by a .45 handgun) had a totally disrupted globe, and three patients (injury in one caused by a .22 rifle and in two by 9-mm handguns) had irreparable ruptured globes that were enucleated at the time of the craniotomy. One additional patient (injury caused by a 9-mm handgun) had a unilateral hyphema and bilateral vitreal and choroidal hemorrhages, all of which resolved without sequelae.

Mandibular, LeFort, and comminuted naso-orbital-ethmoidal fractures were found only in patients who had used a 9-mm or .45 handgun. The patient whose injury was inflicted by a .45 handgun had near-total destruction of one orbit. All the patients who used a 9-mm handgun had complex orbital wall fractures that required repair with multiple bone grafts to maintain the position of the globe or an obli-
Nonfatal self-inflicted gunshot wounds

Candida albicans

Self-inflicted

The muzzle is most often placed against the tissue, when necessary, was confined to one frontal lobe in bridement of bone and bullet fragments and necrotic brain hours of injury in nine patients. One patient underwent an omy in all other patients. This was accomplished within 6 severe intracranial bleeding was the indication for craniotomy. Elevated ICP due to edema and moderate-to-aggressive CT scans of the head are detailed in Table 1 for each patients whose injuries were caused by a 9-mm handgun and the patient whose injury was caused by a .25 handgun had septal perforations.

The intracranial injuries that were diagnosed on preoperative CT scans of the head are detailed in Table 1 for each patient. The untreated .45 handgun injury was believed to have caused the greatest amount of primary parenchymal destruction. Elevated ICP due to edema and moderate-to-severe intracranial bleeding was the indication for cranionomy in all other patients. This was accomplished within 6 hours of injury in nine patients. One patient underwent an emergency frontal ventriculostomy for control of elevated ICP, followed 24 hours later by frontal craniotomy. Debridement of bone and bullet fragments and necrotic brain tissue, when necessary, was confined to one frontal lobe in each case.

In all cases the bullets entered the cranial cavity through the cribiform plate of the ethmoid bone or the orbital plate of the frontal bone. The approximate size of each skull base defect, as measured on preoperative maxillofacial CT scans, is shown in Table 1. Dural injuries, although hard to measure intraoperatively because of the irregularity of their margins, seemed to be proportionate to these bone injuries. By far the largest bone defect was found in the patient wounded by the .45 handgun. The next five largest defects were caused by 9-mm and .38 handguns. The frontal sinus was directly involved in six patients. The sinus was obliterated in one of these patients and cranialized (that is, the posterior table was removed) in four others. The sinus was not surgically entered in one patient whose injury involved only the floor of an extreme lateral recess, or in three patients whose injuries did not involve the sinus. One additional patient underwent cranialization of an unjured sinus as part of the exposure of an adjacent cribiform plate and fovea ethmoidalis defect. Only two patients (Cases 10 and 11) had posterior extension of fractures into the orbital apex and the middle cranial fossa.

All injuries to the dura mater were repaired primarily or by using a fascial patch. All the larger bone defects were repaired using a combination of split cranial bone grafts and a pericranial flap, or a free fascial overlay graft. No complications related to the skull base repair occurred in these patients. Cerebrospinal fluid leaks developed postoperatively through two smaller defects; one of these had been caused by a .22 rifle and one by a .25 handgun. The defects had been covered by pericranial flaps but not by bone. Both leaks stopped several days after insertion of a lumbar catheter for controlled CSF drainage. Nevertheless, the patient with the .25 handgun injury returned 5 weeks later with progressive pneumocephalus related to an ethmoid labyrinth defect. This defect was successfully closed with cartilage and fascial grafts placed through an extracranial, transethmoidal approach.

The frontal bone flap was replaced at the initial surgery in nine patients. A decompressive craniectomy with frontal lobe debridement was subsequently required for one patient (Case 6, injured by a .38 handgun) due to recurrent elevated ICP. This patient underwent an uneventful cranioplasty 2 months later. A decompressive craniectomy was performed as the initial procedure in one patient (Case 10, injury caused by a 9-mm handgun) who was judged to have the most severe frontal lobe injury among the survivors. This patient also had extensive soft-tissue damage at the exit site, and she was the only patient in whom a scalp wound breakdown and intracranial infection (Candida albicans and Staphylococcus aureus) developed. The wound was debrided and closed with rotational scalp flaps, and the mixed infection was treated with intravenous medications. Cranioplasty was performed using calcium phosphate cement 4 months later and the patient did well for 6 months. She again presented with exposure of the cranioplasty material due to apparent self-mutilation, necessitating removal of the alloplast and preparation of the site for future reconstruction.

Nine patients resumed an independent lifestyle that was satisfying to them and their families. The five patients with large skull base injuries caused by either a 9-mm or .38 handgun had subjective anosmia. Three others had intact olfaction, and two patients were not questioned regarding this sense. One patient experienced seizures, which were controlled with anticonvulsant medications 3 months after the injury, and three patients appeared to have a mild expressive aphasias when last seen. The patient who had the most severe frontal lobe injury among the survivors has remained in an assisted-living facility for longer than 2 years because of a moderate cognitive disorder and severe emotional instability. She had a preexisting bipolar affective disorder and was the only patient known to have attempted suicide previously. There was no repeated suicide attempt among the group during the follow-up period.

Discussion

Suicide-related gunshot wounds to the head are associated with a very high mortality rate and severe disability in the few survivors. Overall, a greater chance of death and poorer outcome with survival can be predicted for any patient with a brain injury caused by a self-inflicted gunshot wound compared with patients injured by gunshot wounds that are accidental or delivered in an assault. Self-inflicted gunshot wounds are contact (close-range) wounds, and the velocity of the missile at impact approximates the muzzle velocity of the firearm, ensuring the maximum wounding power of the missile. The muzzle is most often placed against the forehead or temple, and less commonly in the mouth or below the chin. A missile aimed at the brain from a forehead or temple entrance site is likely to pass through multiple lobes in the ipsilateral cerebral hemisphere, penetrate...
the ventricular system, or cross the midline to cause bihemispheric lesions. If the missile track is limited to both frontal lobes, the injury may not be fatal but outcome is extremely poor in survivors. A missile aimed from an oral or submental entrance site usually passes through the brainstem to produce an immediately lethal injury. Survival with the probability of a satisfactory recovery distinguished our patients from most patients who have a brain injury due to a self-inflicted gunshot wound to the head. This difference in prognosis appeared to be related to the choice of firearm and a deviated missile track that did not miss the brain altogether. Each patient used a handgun or a .22 rifle (a relatively low-velocity and, therefore, low-energy weapon) and their aim directed the bullet anteriorly into the frontal region of the brain rather than posteriorly through critical brainstem structures. Bifrontal contusions did occur in several patients, but the missile track through the brain and any resultant parenchymal damage that required debridement were confined to one frontal lobe. Larger-caliber bullets, which perforated the deeper substance of the frontal lobe, rather than just its surface convexity, appeared to cause the greatest amount of primary destruction of brain tissue, and patients with these injuries tended to have a more unfavorable prognosis. Of note, during the same time period, no patients arrived alive in our emergency department after having used a high-energy rifle or shotgun to inflict an oral or submental wound with a missile track that penetrated the brain.

The paramedics’ recognition at the scene of the shooting of the need for airway control was critical in the prehospital stabilization of each patient. Orotracheal intubation was the first choice for creation of an artificial airway, even when the oral airway was compromised by blood and debris from the tongue, the floor of the mouth, and palatal injuries. No surgical airways were required until definitive management of the more complex facial injuries. Many of the patients had little if any external evidence of the passage of the bullet through the face. Nevertheless, sight-threatening injuries were seen. Ophthalmological injuries, some potentially reversible with prompt treatment, occurred with a variety of the weapons used. Larger-caliber bullets tended to produce a wide pattern of comminution and loss of bone in the mandible, maxilla, and orbits, as well as in the anterior skull base. Failure to isolate the dural repair overlying a skull base injury from the nose and paranasal sinuses adequately led to several possibly preventable intracranial complications. In our hands, the use of a pedicled pericranial flap combined with contoured cranial bone grafts was more successful in sealing the skull base than a pericranial flap alone.

Conclusions

Self-inflicted submental and transoral handgun and lowenergy rifle wounds may produce serious but survivable brain injuries if the path of the bullet is limited to the frontal area. Early, aggressive management of the brain, dural, and craniomaxillofacial injuries should return the patient to a highly functional neurological status and restore an acceptable outward appearance. We believe that the importance of associated injuries should not be minimized as this type of patient is being prepared for an urgent craniotomy, nor should management of these injuries be deferred because of any doubts regarding salvageability. Repairs of facial injuries were sequenced in all our patients with the craniotomy and management of the brain and dural injuries. Although the decision to perform a lengthy maxillofacial reconstructive procedure might be controversial, it did not appear to affect neurological outcome adversely in any patient. The subfrontal exposure that was required for brain debridement and dural repair actually facilitated orbital and naso-orbitoethmoidal reconstructions, and these initial fracture repairs eliminated the need for secondary procedures that might have caused additional trauma to the brain or disrupted a successful dural repair. The decision to proceed in each case should be the responsibility of the neurosurgeon, based on an assessment of brain swelling and hemodynamic stability. Overall, outcomes appear to be much better for these patients than for most patients with a penetrating brain injury due to a self-inflicted gunshot wound.

References

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