Pediatric Nonmissile Penetrating Head Injury: Case Series and Literature Review

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Key words
- Head injury
- Nonmissile
- Pediatric
- Penetrating

Abbreviations and Acronyms
AVF: Arteriovenous fistula
CNS: Central nervous system
CT: Computed tomography
CTA: Computed tomography angiography
DSA: Digital subtraction angiography
FB: Foreign body
GCS: Glasgow Coma Scale
GOS: Glasgow Outcome Scale
ICP: Intracranial pressure
IV: Intravenous
NMPHI: Nonmissile penetrating head injury
PBI: Penetrating brain injury
SAH: subarachnoid hemorrhage
TICA: Traumatic intracranial aneurysm

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BACKGROUND: **Pediatric nonmissile penetrating head injury (NMPHI) is usually accidental attributed mainly to the softer skulls of growing children. However, it is a rare entity, and therefore no consensus exists regarding treatment to effectively prevent immediate and long-term complications. Throughout the literature, these injuries are mostly discussed in case reviews and case series in the general population. No data originating from randomized studies are available because of ethical and practical limitations.**

METHODS: **We retrospectively studied and present 5 cases of children with NMPHI treated in the last 6 years in the Neurosurgery Department of Children's Hospital "Aghia Sofia". We performed a review of the literature in PubMed, using the key words "non-missile," "penetrating head injury," and "pediatric." We included case reports and case series involving pediatric cases since 2008 and selected older reports as well as certain literature reviews focusing on analysis of complications and treatment suggestions. We compared reported practice in various institutions with suggestions from the literature.**

RESULTS: **In the last year, 4 literature reviews were published suggesting treatment algorithms of NMPHIs. Surgery timing and method as well as anti-convulsant and antibiotic therapy still remain debatable. The only review concentrating on pediatric populations dates back to 1994, based on patient outcome studies from the 1980s. In our review, treatment steps were similar among various institutions and resembled recently suggested algorithms, with better treatment outcomes than originally reported 30 years ago.**

INTRODUCTION

Traumatic brain injury in children may occur as a result of various mechanisms. It could be periambulatory or an accident while playing, but it could also be a result of violence (e.g., child abuse or shaken baby syndrome). Central nervous system (CNS) injuries tend to be milder in children (1–15 years old) than in adults and are the leading cause of death in the 1-year to 40-year age-group.[1] Penetrating head injuries are rare[2] and fatal in 40% of cases.[3] Although in the Western world, they usually occur as gunshot wounds, in the developing world they commonly appear as sharp nonmissile wounds because of strict rules concerning gun possession.[4]

Nonmissile injuries are defined as those caused by objects traveling at a speed <100 m/second.[3] They represent 0.4% of overall head trauma.[5] In children, they are usually a result of accidents while playing with sharp objects.[2] The most common entrance site is the roof of the orbit because of its thinner wall, followed by the squamous part of the temporal bone.[5] Several materials inserting the skull have been reported. The list includes nails, metallic screws, stones, metallic rods, wooden sticks, chopsticks, pencils, knives, scissors, arrows, and other objects with a sharp edge.[6]

The result of a penetrating injury to the head is direct damage to the brain or its vessels, resulting in high morbidity and mortality. Almost 40% of fatal cases do not reach hospital.[5] Complications reported include hematoma formation, contusions, and subarachnoid hemorrhage (SAH) resulting in seizures and variable degree of neurologic damage, depending on their location. Moreover, vascular lacerations with aneurysms or arteriovenous fistula (AVF) formations have been reported, as well as infection with meningitis or abscess formation, especially with certain types of material such as wooden objects.[6]

In this article, we present 5 cases of children, 3–14 years old, with penetrating nonmissile head injuries treated in the neurosurgical department of the pediatric hospital "Aghia Sofia" in Athens from 2010 to 2016. The cases cover a broad spectrum of the types of injuries reported in various medical journals. We have performed a review of the literature with similar cases in an attempt to compare treatment selection and patient outcomes among similar cases.

There has been no consensus regarding the initial management, treatment and follow-up of these patients.[7] However, with the availability of similar diagnostic tools such as computed tomography (CT), magnetic resonance, and angiography, and with the universal use of emergency protocols such as advanced trauma life support and definitive surgical trauma care, case reports and case series of the last decade tend to report similar management algorithms. Subsequently, the first reviews attempting to suggest an overall treatment for penetrating head injuries have recently been published.[6,8] Our review is the first concentrating on the pediatric population and an attempt is made to adopt previously suggested treatment modalities to this special population.

CASE DESCRIPTIONS

Case 1

A 4-year-old girl was brought to the emergency department by her parents because of an accident while playing. The parents reported that the wind blew a large glass door while the child was playing nearby. A piece of glass from the door hit the patient on the head. No loss of consciousness or vomiting was reported (Figure 1).

On admission to the emergency department, the patient had a Glasgow Coma Scale (GCS) score of 15/15. She was crying and was able to follow simple commands. Vital signs were normal. Clinical examination showed a shard of glass penetrating the right frontal area. Neurologic examination was normal and no deficit was recognized. CT of the brain showed a foreign body (FB) perforating the right frontal bone and inserting the right frontal lobe. A small subdural hematoma around the FB was recognized, accompanied by small pneumocephalus.

Intravenous (IV) antibiotics (IV vancomycin, ceftriaxone, and metronidazole) and antiepileptic therapy (IV levetiracetam) were immediately initiated and she was transferred to the operating room. With the patient under general anesthesia, the part of the glass outside the skull was cut using an osteotome, and proper cleaning and draping of the surrounding area was applied. A bicoronal skin incision and a craniotomy 5 cm × 6 cm around the glass were performed. The glass was removed attached to the bone flap, using a gripper to stabilize it. The dura was opened and approximately 20 mL of subdural hematoma was evacuated. Two small bone fragments were recognized and removed from the brain tissue. Copious irrigation and meticulous hemostasis were performed. The bone was placed back, stabilized with sutures (vicryl 2.0), and the skin was closed in a normal fashion.

Postoperative CT did not show any residual FB or hematoma. The child made an uneventful recovery with no neurologic deficit. Antibiotics and antiepileptic drugs were administered throughout her stay. She was discharged 10 days later. At the 1, 3, and 6 months follow-up reexaminations, everything was normal, with no neurologic deficit and normal growth rates.

Figure 1. Piece of glass protruding from the forehead of the patient.

Case 2

A 6-year-old boy presented to our emergency department with a hook penetrating the back of his head, as a result of an incident occurred while fishing with his father. On admission, the patient was agitated but fully oriented, able to follow simple commands. Physical examination showed a 5-cm fishhooklike object, lodged in the parietal region close to the midline with no sign of hemorrhage or local inflammation. Neurologic examination was normal. CT showed penetration of the parietal bone 4 cm over the occipital protuberance, close to the superior sagittal sinus. Neither dural penetration nor hematoma was evident. However, because the metallic nature of the FB and the artifacts it created, the examination was considered of low diagnostic quality.

The patient was transferred to the operating room. All preparations had been made for a possible penetrated superior sagittal sinus. After a skin incision, the entry point of the FB was evident. The bone was not fully penetrated, and therefore removal of the FB was easy and no craniotomy was deemed necessary. The subcutaneous tissues were copiously