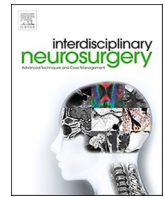




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Accidental pneumatic nail gun brain injury in a teenager: A case report and review of the literature

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ABSTRACT

Background: Pneumatic nail gun brain injury has been increasing in recent years. This injury may accidentally occur by pneumatic nail gun devices or after a suicide attempt. Most pediatric patients develop nail gun brain injury after an accidental event.

Case description: We presented a 16-year-old teenager with an accidental brain injury caused by a pneumatic nail gun. In our patient, a six-cm-nail penetrated the right parietal lobe obliquely from the left parietal region. The patient underwent a craniotomy, and the nail was removed from his head. During the operation, mild hemorrhages developed on the lateral wall of the sagittal sinus, which was controlled using gel foaming. The patient was discharged with mild hemiparesis in his right lower limb.

Conclusion: In most patients, craniotomy is the preferred technique for removing the nail after a nail gun brain injury. Minimally invasive surgery may be a feasible choice in selected patients for whom the end of the nail is available without other brain injuries such as vascular damage, bone fracture, or decreased level of consciousness.

1. Introduction

Between 2001 and 2005 about 37,000 cases of pneumatic nail gun injury occurred in the US, and upper limb injury was the most common subsequent injury. Nail gun brain injury accounts for a small proportion of this type of injury [1]. In a review of the patients with nail gun brain injury between 1960 and 2018, 80 cases were reported. Of these, 97.5 % were young males, and 54 % occurred following a suicide attempt. The mortality rate was 10 %, and the complication rate, including vascular damage, brain infections, and seizure, was 23.8 % [2]. In another review of 40 patients with penetrating brain injury between 2011 and 2015, nail gun brain injury occurred in five patients, including three children. Two out of three children were successfully treated by craniotomy, and one child was treated by primary removal of the nail without craniotomy [3]. Despite the frequency of penetrating brain injury, only a few reports of nail gun brain injury in adults and seldom reports in children have been published. The severity of nail gun brain injury varies from mild trauma to a fatal event. Most nail gun brain injuries occur following

accidental events or suicide attempts. In a review of 35 children with nonmissile penetrating head injury, two children had nail gun brain injury, and both were treated successfully by craniotomy [4]. We presented a teenage boy with an accidental pneumatic nail gun brain injury who was treated by craniotomy. We also performed a thirty-year review of all published cases of nail gun brain injury in the PubMed database since 1993. We excluded other penetrating brain injuries caused by chopsticks, knives, curtain rails, and stone injuries.

2. Case presentation

2.1. Clinical presentation

A 16-year-old male was referred to the emergency department with an accidental penetrating brain injury in a workhouse by a pneumatic nail gun. On admission, he had a Glasgow Coma Scale (GCS) of 14/15, pulse rate of 128 beats per minute, respiratory rate of 22 per minute, and blood pressure of 96/54 mmHg. His pupils were normal and reactive,

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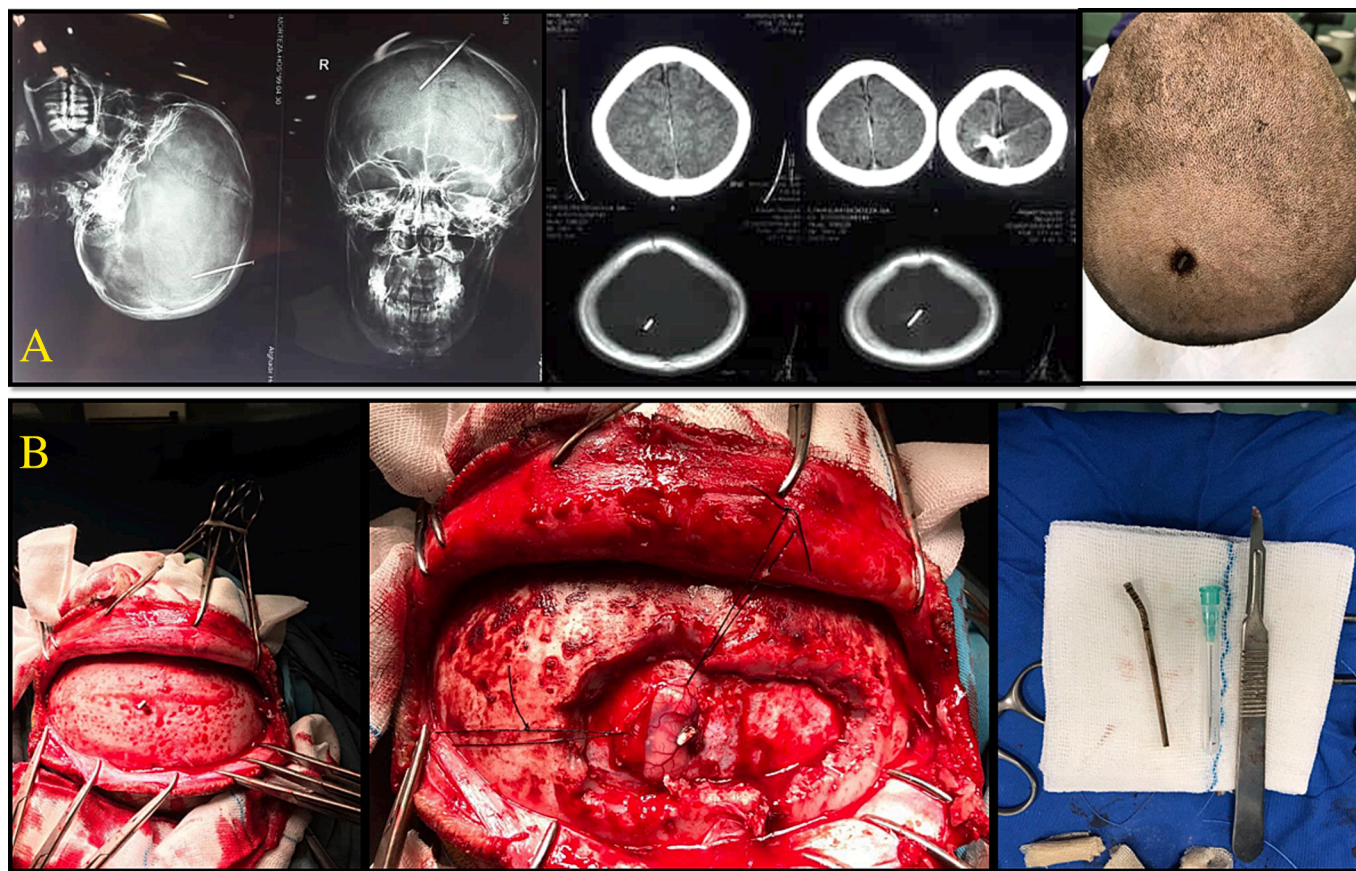


Fig. 1. (A) The plain X-ray showed an oblique nail penetrated from the left lobe to the right parietal lobe. Computed tomography did not show intracranial bleeding. The nail entrance was visible at the left parietal scalp. (B) The nail was visible without bleeding after scalp incision and craniotomy. A six-centimeter nail was entirely removed by surgery.

and his eye movements were intact. Physical examination revealed a small hematoma on her occipital scalp.

2.2. Diagnostic assessment

The plain skull radiograph showed a six centimeters nail inserted obliquely from the left to the right parietal lobe, and the brain computed tomography revealed no intracranial hemorrhages (Fig. 1A).

2.3. Management

The initial management included hydration, parenteral anticonvulsant, broad-spectrum antimicrobial treatment with ceftriaxone and vancomycin, and tetanus prophylaxis. After initial management, the patient underwent a craniotomy. The surgery started with a linear bilateral parietal incision to expose the skull. After that, local debridement of the necrotic tissue was performed, and the superficial hematoma was cleaned. The skull bone around the nail was removed, and a U-shaped incision was performed for opening the dura and removing the hematoma around the entrance of the nail. No active hemorrhage was found at the time of surgery. The neurosurgeon physician considered that the nail should affect three anatomical brain areas, including the left and right parietal lobe and sagittal sinus. So he estimated that about two centimeters of the nail penetrated each area and planned three removal steps. He gently pulled the nail out from the right parietal lobe in the first step. Then, he gradually removed the nail from the sagittal sinus. A mild hemorrhage originating in the lateral sinus wall occurred in this step. So, he repaired it primarily using gel foaming. Finally, after ensuring hemostasis, the nail was removed entirely from the left parietal

lobe. During the craniotomy and after pulling out the nail, the brain tissue was washed with seven liters of saline (Fig. 1B). The surgery ended with duraplasty and cranioplasty.

2.4. Outcome

The patient was hospitalized for five days after the surgery for IV antimicrobial and anticonvulsant drugs. He was discharged fully conscious without signs of hemorrhage or secondary infection, but his right lower limb force was III/VI.

2.5. Follow-up

We visited the patient two weeks and two months after discharge. His hemiparesis recovered relatively, and the right lower limb force reached IV/VI and V/VI, respectively.

3. Discussion

3.1. Accidental nail gun brain injury

We reported a teenage boy with a pneumatic nail gun brain injury during an occupational accident who was successfully treated by craniotomy. Pneumatic nail gun devices are found in many industrial workshops, and accidental trauma or suicide attempt by these devices is increasing. Accidental nail gun injuries can occur in any part of the skull. In a case series from China, three men developed accidental nail gun brain injuries in the parietal and occipital lobes [5]. A 70-year-old man in Mexico accidentally developed nail gun brain trauma in his sagittal

Table 1
Pediatric cases with penetrating nail gun brain injury.

Reference	Age	Sex	Primary GCS	Entry	Brain Injuries	Outcome	Surgical Technic
Heiferman, D [9]	1	Female	14	Anterior fontanelle	injury to the right superior colliculus	Favorable	Craniotomy
Yazar, U [10]	2	Male	15	Right Temporal	None	Favorable	Craniotomy
Regunath K [11]	3	Female	15	Right frontal region	None	Favorable	Craniotomy
Sedney, C [12]	4	Male	15	Coronal suture	Sagittal sinus injury	Favorable	Craniotomy
Evangelos, D [13]	14	Male	6	Left temporal, Left orbit	Hematoma	Favorable	Craniotomy
Luo, W [14]	15	Male	15	Left parietal	ICH	Favorable	Craniotomy
Our case	16	Male	14	Parietal	None	Favorable	Craniotomy

Table 2
Adults cases of penetrating nail gun brain injury following a suicide attempt.

Reference	Age	Sex	Primary GCS	Entry	Brain Injuries	Outcome	Surgical Technic
Alain, J [15]	50	Male	13	Bitemporal	ICH, Hemorrhage	Favorable	Craniotomy
Aghabiklooei, A [16]	48	Male	15	Bitemporal	ICH, SAH	Favorable	Craniotomy
Zhu, RC [17]	30	Male	15	Temporal	None	Favorable	Craniotomy
Bock, H [18]	NA	Male	8	Temporal, Occipital	Multi nail	Favorable	NA
Englot, DJ [19]	51	Male	15	Temporal	Distal Basilar Artery Hemorrhage	Favorable	Craniotomy
Chen, PC [20]	91	Male	5	Frontal	CVA, SDH	Poor	Craniotomy
Kim, TW [21]	56	Male	13	Biparietal	SAH, Multi nail	Favorable	Limited Surgery
Selvanathan, S [22]	37	Male	15	Auditory Canal, Temporal	None	Favorable	Limited Surgery
	52	Male	15	Frontal	Multi nail	Favorable	Limited Surgery
Testerman, GM [23]	50	Male	15	Temporal	Multi nail	Favorable	Craniotomy
Carnevale, JA [24]	60	Male	15	Temporal	SAH, Multi nail	Favorable	Craniotomy
Patnaik, A [25]	19	Female	15	Frontal	None	Favorable	Craniotomy
Thawani, JP [26]	64	Male	3	Frontal, Temporal, Parietal	SAH, ICH, IVH, Multi nail	Poor	Craniotomy
Lee, CS [27]	62	Male	15	Parietal, Parasagittal	Multi nail	Favorable	Limited Surgery
Oh, HH [28]	46	Male	3	Temporal	ICH	Poor	Craniotomy
Andereggen, L [29]	48	Male	15	Nasal Cavity, Frontal	None	Favorable	Craniotomy
Yuh, SJ [30]	33	Male	15	Bitemporal	Multi nail	Favorable	Craniotomy
Litvack, ZN [31]	33	Male	15	Temporal	Multi nail	Favorable	Limited Surgery
Makoshi, Z [32]	33	Male	15	Bitemporal	Multi nail	Favorable	NA
	51	Male	8	Bitemporal	Multi nail	Poor	NA
	22	Male	15	Frontal	None	Favorable	NA
	49	Male	15	Auditory Canal	None	Favorable	NA
Rofail, M [33]	54	Male	NA	Frontal, Orbital Cavity	Multi nail	Favorable	Craniotomy
Jeon, YH [34]	43	Male	14	Parietal	None	Favorable	Craniotomy
Viswanathan, R [35]	52	Male	<12	Frontal	Bone fracture	Poor	Craniotomy
Agu, CT [36]	23	Male	15	Temporoparietal	None	Favorable	Craniotomy
Ye, CN [37]	58	Male	15	Frontotemporal	ICH, SAH	Poor	Craniotomy
Luo, W [14]	20	Male	15	Temporal	Bone fracture	Favorable	Craniotomy

Abbreviation: ICH (Intra cranial hemorrhages), IVH (Interventricular hemorrhages), SAH (Subarachnoid Hemorrhages), CVA (Cerebrovascular accident), NA (Not available), SDH (Subdural hematoma).

sinus [6]. A 28-year-old man in California was accidentally injured in his occipital and parietal lobes led to a posterior sagittal sinus injury [7], and two young males, 15 and 20, were accidentally injured by a nail gun in the temporal and parietal lobes [8]. Accidental nail gun brain injuries are more common in children and young adults. In most cases, except in patients with major vascular injuries, this type of injury keeps a favorable outcome (Table 1).

3.2. Self-induced nail gun brain injury

In contrast to accidental nail gun brain injury, self-induced nail gun brain injuries occur due to a suicide attempt, especially in patients with a history of schizophrenia or depression. In these cases, a patient usually shoots himself in the temporal part of the skull and occasionally with several nails (Table 2).

3.3. Diagnosis and treatment strategy

The severity of the injury and initial GCS are two clinical indices for the possibility of intracerebral hemorrhages or vascular injury. Although many authors recommend that cerebral angiography should be performed in all patients before the surgery, the unavailability of angiography in many centers, and the lack of clinical or radiological evidence of intracranial hemorrhages in most patients, many physicians do not

request this procedure, as we did not do that [8]. Surgical intervention is the main part of treating patients with pneumatic nail gun brain injuries; however, rare cases have been treated only by decontaminating the entry site of trauma, antibiotics, and anticonvulsant drugs, without removing the nail. This approach may be applied in a neurologically stable patient with deep penetration of the nail and the possibility of severe nerve damage related to the surgery. Two main techniques usually perform for nail removal. The first technique is craniotomy to assess cerebral tissue damage, intracranial hemorrhage, debridement of the necrotic tissues or hematoma, and removal of the nail in most patients. The second technique, performed in a small minority of patients, is simple blind traction of the nail. The latter should be performed only in patients without neurological deficits whose nail's tip is accessible and no clinical or radiological evidence of hemorrhages or associated injuries, such as a depressed fracture or cerebral contusion, are present [3,37].

Infectious complications (including meningitis and brain abscess) and seizures are the most common complications associated with penetrating brain trauma, which occurs in 55 % and 30 % of patients, respectively [37]. However, the frequency of these complications in pneumatic nail gun brain injury has not been well define.

We suggest performing a systematic review and meta-analysis to investigate the types of brain damage and the best treatment option in pediatrics and adults with nail gun brain injuries.

4. Conclusion

Pneumatic nail gun brain injury should be treated individually. Surgical intervention is the treatment of choice for the removal of the nail. But, the selection of the surgical technique is affected by many factors, especially the visibility of the nail tip, the presence of intracranial hemorrhage, and the severity of brain injury.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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