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Case Report

Double penetration wound: A nail gun injury involving the head and heart

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ABSTRACT

Nail gun injuries usually occur at the extremities due to working accidents. Intracranial or intrathoracic injuries are relatively rare, and cases combined with both injuries are even rarer. Such situations pose challenges for surgeons due to their uniqueness during operation. Radiologic imaging findings in our case were significant in indicating surgical findings. Herein, we report a patient who shot himself using a nail gun, damaging his brain and heart.

Introduction

Nail gun injuries involving vital organs, especially those involving the brain or heart, often result in severe wounds and require surgical interventions immediately. Despite the traumatizing results, nail gun injuries have a better outcome compared with other penetrating injuries, such as those caused by knives or bullets [1]. Imaging techniques, especially computed tomography (CT), are often required either to survey the wound or to plan surgical procedures and sometimes predict the outcome for the patient. We report a case of a double-nail gun penetration injury involving the cranium and the thorax. The patient did not lose consciousness at the scene, and his conscious was clear throughout his journey from his home to the hospital. Imaging results of the chest in our case revealed the related positions between the penetrated nail and the coronary artery (which were adjacent but not encountered), predicted surgical findings, and helped arrange treatment methods in our case. Median sternotomy instead of thoracotomy was performed for a better surgical view due to penetration of the left ventricle, which was also shown on the CT. Cardiopulmonary bypass (CPB) machines were not used in our case while repairing the heart due to simultaneously presenting hemorrhagic brain injury, which is quite the opposite in regular surgical heart repairs [2]. By this case, we would like to share our imaging findings and consequent management methods with readers and specialists in associated fields.

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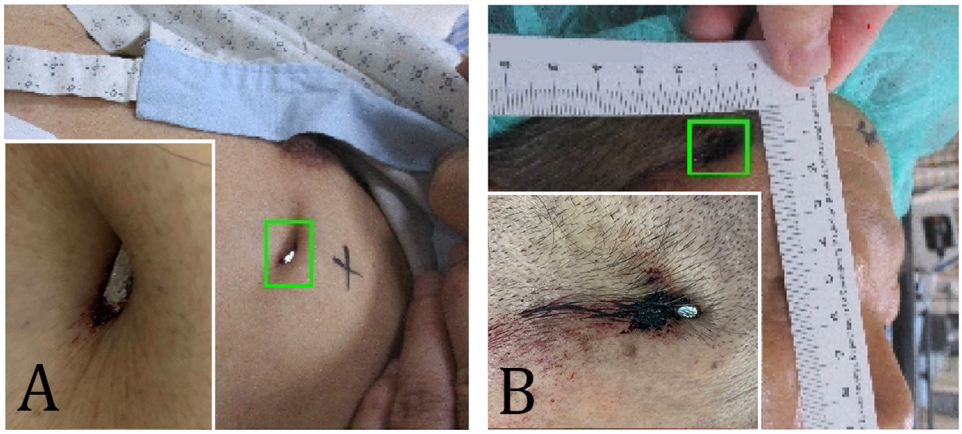

Fig. 1 – (A) Clinical image of a nail penetrating through the patient's left chest with a closer view. (B) Clinical image of the other nail penetrating through the patient's right temple with a closer view.

Case description

A 58-year-old man had underlying diseases of multiple old cerebral vascular infarctions, coronary 2-vessel-disease post stenting, type 2 diabetes mellitus, hypertension and end stage renal disease (ESRD). Two days after being diagnosed with major depression disorder, he committed suicide by shooting himself twice with a pneumatic nail gun. The first shot was in the chest, and after finding himself still alive, he shot himself again in the head. These nails were stainless, with 50 mm in length and 2 mm in diameter. He was discovered after 6 hours in his bathtub alone and sent to the emergency department (ED), without losing consciousness (Glasgow Coma Scale: E4V5M6) and limb weakness. After being transferred to the ED, he complained of headache and chest pain. Two penetrating wounds were found in the left chest and the temple around the right forehead, without gross external bleeding from the wounds (Fig. 1). Chest x-ray and CT revealed a nail penetrating the left lower anterior chest wall to the heart with significant hemopericardium (Fig. 2). Brain CT revealed intracranial hemorrhage (ICH) in the right frontal lobe and subdural hemorrhage at the right frontotemporal region (Fig. 3). Emergent operation was then arranged.

After median sternotomy was performed, a massive bleed was noted after opening the pericardium. The left ventricular (LV) rupture site was adjacent to the left anterior descending (LAD) artery, which was intact at first glance. After removing the nail, we repaired LV with Teflon felt interrupted mattress sutures immediately.

Next, we performed a craniotomy around the nail (Fig. 4). After removing the nail, we cleaned the hemorrhage of subdural hemorrhage and ICH. Hemodynamics were stable during and after operation, and we arranged intensive care unit admission afterwards.

After emergent operation, this patient's hemodynamic status was stable and neither cardiac arrhythmia nor ischemia signs noted. Intracranial pressure monitor data was stable during postoperative period. Postoperative brain CT showed absorption of right frontal region ICH. However, patient did not recover his consciousness after we stopped sedative medications. Around 20 days after operation, his family decided to give up and withdrawal life supports.

Discussion

Penetrating intracardiac injury

Mortality rates of intracardiac penetration injuries vary depending on the penetrating object. Nail gun injuries penetrating the heart have a mortality rate of up to 25% [1]. Mortality rates of stabbing injuries of the heart range from 22% to 62%. Gunshot injuries have a higher mortality rate from 60% to 95% [1].

CT of the head and chest were done upon arrival at the ED, and in the axial and sagittal views, we could clearly see the left descending branch of the coronary artery, as in Figure 2B. Comparing the site of the LAD branch and the nail penetrating the heart, it could be seen that though adjacent, the nail did not penetrate the LAD of the coronary artery. By viewing the image results, prediction of the findings during surgery could be made, which was validated in our patient.

The projectile speed of a nail gun can range from 150 ft/s (45.7 m/s) (pneumatic nail gun) to 1400 ft/s (426.7 m/s) (powder-actuated tool). The former and the latter are used for driving nails into wood and concrete/metal, respectively. Even though the velocity can reach as high as a handgun (700 ft/s) (213.4 m/s) [3], the lateral distribution energy of nail guns is limited and most of the trauma develop along the route of penetration [4]. Unlike nails, a bullet will spin when shot, which deals more lateral distribution damage to the tissue.

When the penetration injury involves the heart, right ventricle (RV) injuries are most reported [5], which was different from our case (LV). The reason might be the penetration angle being more lateral caused by our patient. The chamber pressure of LV is higher than RV, which might not only cause more severe hemopericardium, but also make it harder to repair if penetrated. The technique used in repairing an RV-penetrating injury often involves purse string suture to prevent bleeding and pledget to minimize tear during nail

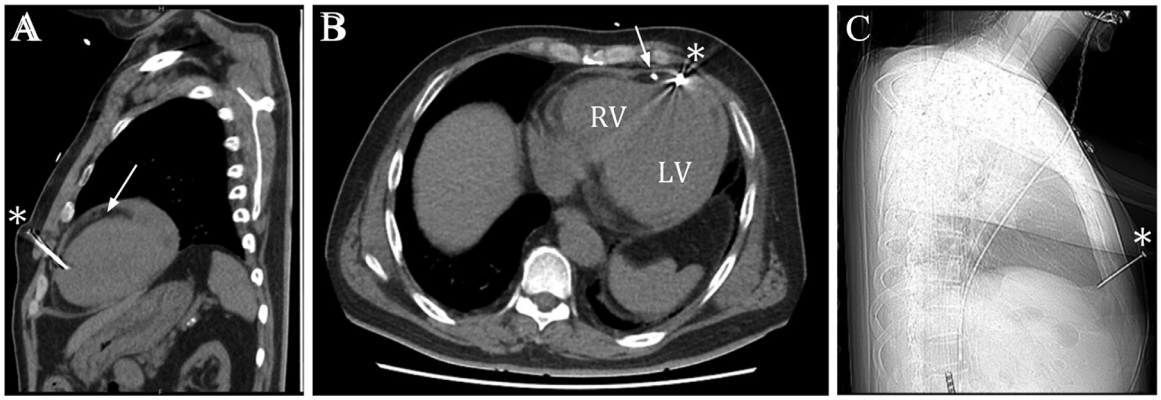

Fig. 2 – (The nail is marked as asterisk*).
(A) Sagittal view of chest CT, revealing a nail penetrating through the ventricle causing hemopericardium (arrow).
(B) Axial view of chest CT. Left anterior descending branch of coronary artery (LAD, marked as arrow) can be seen due to severe calcification. Penetration into the left ventricle (LV) was confirmed since it is located lateral to the LAD.
(C) Lateral view of chest x-ray, revealing a nail penetrating through the chest wall. CT = computed tomography, LAD = left anterior descending.

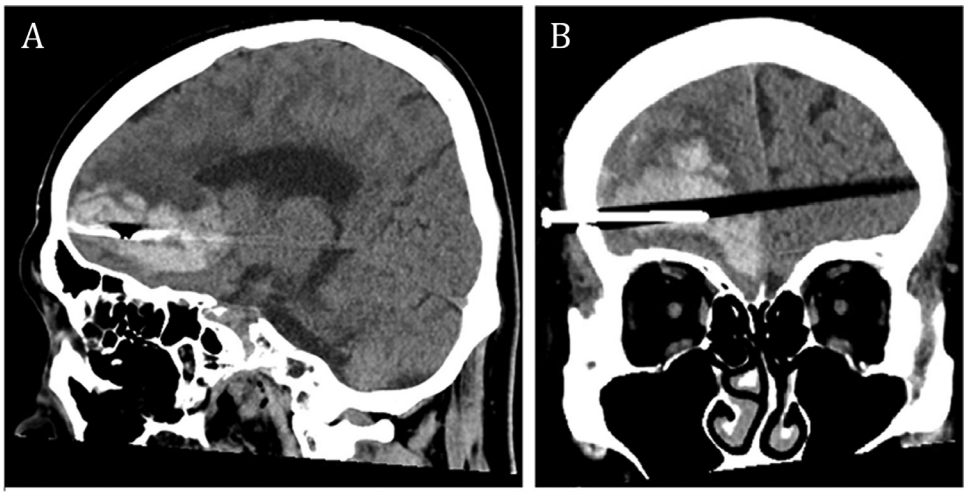

Fig. 3 – (A) Sagittal CT view of the head, revealing ICH in the right frontal lobe.
(B) Coronal CT view revealing a nail penetrating from right frontal skull, causing significant beam-shaped artifact.
CT = computed tomography, ICH = intracranial hemorrhage.

removal. A purse string suture around the penetrating site can be simultaneously closed as the nail is withdrawn [3]. However, unlike RV, such technique is difficult to apply in repairing LV, since LV cannot be directly seen during median sternotomy. We need to rotate the heart medially to expose LV, remove the nail from LV, and finally perform Teflon felt interrupted mattress sutures immediately to minimize bleeding.

For penetrating cardiac nail gun injuries, the most commonly preferred surgical options are sternotomy or thoracotomy [3], and the choice is up to the surgeon. In our case, sternotomy was chosen due to better view of LV and bigger space for a heart-lung machine if needed. In order to minimize harm to the heart during nail removal, it is recommended that intravenous adenosine be utilized to reduce the heart rate and continuous transesophageal echocardiography be applied to assess the timing of nail removal, particularly in certain situations when the interventricular septum is involved [6]. In our case, however, the nail did not penetrate through the interventricular septum, so transesophageal echocardiography and adenosine were not mandatory.

After operation, the medical team should be aware of possible postoperative arrhythmia. Panicker et al stated that atrial flutter was identified in their case and the patient was treated with amiodarone [3]. In our case, an amiodarone pump was used due to developing atrial fibrillation 1 day after surgery. Sinus rhythm returned after 4 days of continuous use of the amiodarone pump.

Penetrating brain injury

The velocity of most nail guns is often enough for the nail to penetrate through the skull [7]. However, most pa-

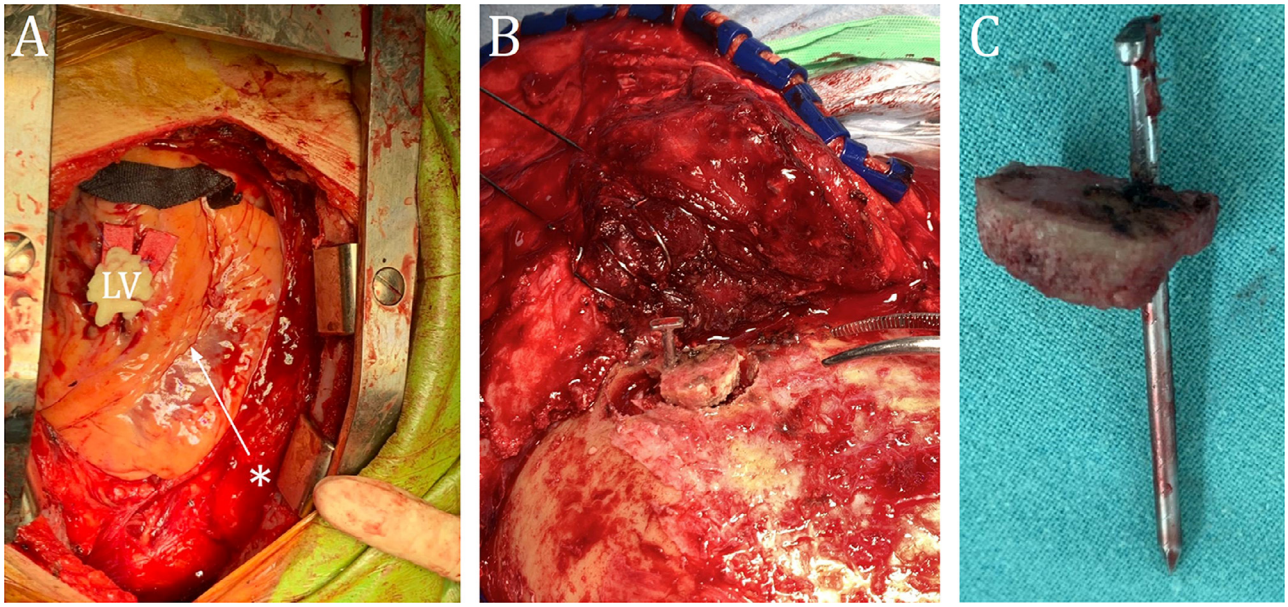

Fig. 4 – (A) Repairing LV and removing nail with purse string suture and pledget after median sternotomy. Left anterior descending branch was intact during operation (marked as asterisk*).
(B and C) Performing craniotomy around the nail. LV = left ventricle.

tients present clear consciousness when sent to ED [8], and mortality following these intracranial nail injuries are low [9]. This might be due to the limitation of lateral distribution damage caused by the nail [4], which was discussed above.

Brain CT is essential for examining nail locations and ICH [10,11]. However, significant artifact is frequently present if there are too many nails [8], which could also be seen in our patient.

Surgical procedures for nail removal include craniotomy or simple blind extraction. Craniotomy is strongly suggested if a nail is totally embedded in the brain [12]; while simple blind extraction could be considered if the head of the nail is outsides the skull [13–15], but complicated delayed ICH has been reported in some studies [16–18]. No matter which surgical option is adopted, a continuous intracranial pressure monitor is suggested if at all possible [19].

Postoperative complications for penetrating brain injury include infection and epilepsy. The percentage of infectious complications, such as wound infection, cerebral abscess and meningitis, is around 55% and 90% within 3 and 6 weeks, respectively [20]; therefore, prophylactic tetanus and broad-spectrum antibiotics should be initiated as early as possible [19,21]. However, there is still no consensus on how long antibiotics should be administered, with estimates ranging from 7-14 days [22] to 6 weeks [21,23].

The percentage of epilepsy after penetrating brain injury is around 30%-50% [21]. Prophylactic anticonvulsants are recommended for preventing early posttraumatic epilepsy [19,24,25], but their potency in preventing late post-traumatic epilepsy remain controversial [12,26]; consequently, it is advised to use prophylactic anticonvulsants like valproate for around 7-10 days only [19,24,25].

Brain protection during cardiac surgery

Most cardiac operations involving heart valves require transient cardiopulmonary arrest, in which CPB was applied [2]. However, the brain, which is highly susceptible to hypoxia, is at risk of thromboembolism, hypoperfusion, and inflammation during CPB [2]. In order to counter these adverse events, anticoagulants, hypothermia, and systemic glucocorticoids are suggested while employing CPB [2].

In our case, which was complicated with ESRD and ICH, usage of anticoagulants was extremely risky. Patients with ESRD have bleeding tendency due to platelet dysfunction [27], which makes hemostasis for ICH harder in our case. Since the ventricles were not penetrated in our patient, we decided to repair the heart off-pump, meaning with the heart beating during operation.

Conclusion

We report a case of nail gun injury involving both heart and brain. Chest CT imaging findings assisted surgeons in surveying the coronary arteries relative to the penetration wound and planning surgical procedures. As far as intracardiac penetrating injury is concerned, CPB is often utilized when repairing such injuries; however, brain damage caused by hypoperfusion and thromboembolism during CPB cannot be underestimated, especially when there is already brain injury present (noted in our case). Anticoagulants for thromboembolism prevention were considerably risky in our case due to severe coagulopathy caused by ESRD, which was the reason we elected to repair the heart off-pump. In this research, we would like to share our experience in image findings and

adoption of a more favorable strategy if similar cases are to be encountered.

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