Case Report

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# Endovascular treatment of penetrating nail gun injury of the cervical spine and vertebral artery: a case report

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In this report, we present a case of high cervical penetrating trauma with vertebral artery injury and outline preprocedural, procedural, and postprocedural considerations with recommendations for the treatment of similar injuries. Management involves multiple imaging modalities, including X-ray imaging, computed tomography, computed tomography angiography, magnetic resonance imaging, and catheter angiography. We recommend endovascular treatment of these injuries when possible, based on the improved ability to achieve proximal and distal control and manage hemorrhage risk.

**Keywords:** Vertebral artery; Wounds and injuries; Therapeutic embolization; Cervical vertebrae; Case reports

## INTRODUCTION

The increased utilization and accessibility of nail guns have been accompanied by a parallel increase in the number of emergency department visits resulting from nail gun-related accidents in both consumers and construction workers [1]. Primary injuries tend to be located in the upper extremities, particularly the hands and digits, although numerous case reports have described facial, cranial, and low cervical injuries. However, a paucity of literature exists regarding high cervical spine injuries with vertebral artery involvement [1–6]. Here, we report a rare case of a high cervical spine nail gun injury with unilateral vertebral artery involvement treated with vertebral artery embolization and subsequent removal of the nail projectile.

## CASE REPORT

### History and presentation

The patient was a 50-year-old right-handed man with no significant past medical history. He was transported to the emergency department by family after an alleged accidental nail gun discharge when he dropped the nail gun while framing a home, embedding a nail in his right upper neck below the ear (Fig. 1A). The patient reported neck pain and a decreased range of motion when looking right. He had no headaches, nausea, vomiting, changes in vision, weakness, paresthesia, or bowel/bladder incontinence. Examination revealed that he was neurologically intact and his head was rotated slightly to the left. The nail head was visible above the skin with notable indentation of the surrounding tissue. No signs were present of acute blood loss or hemato-

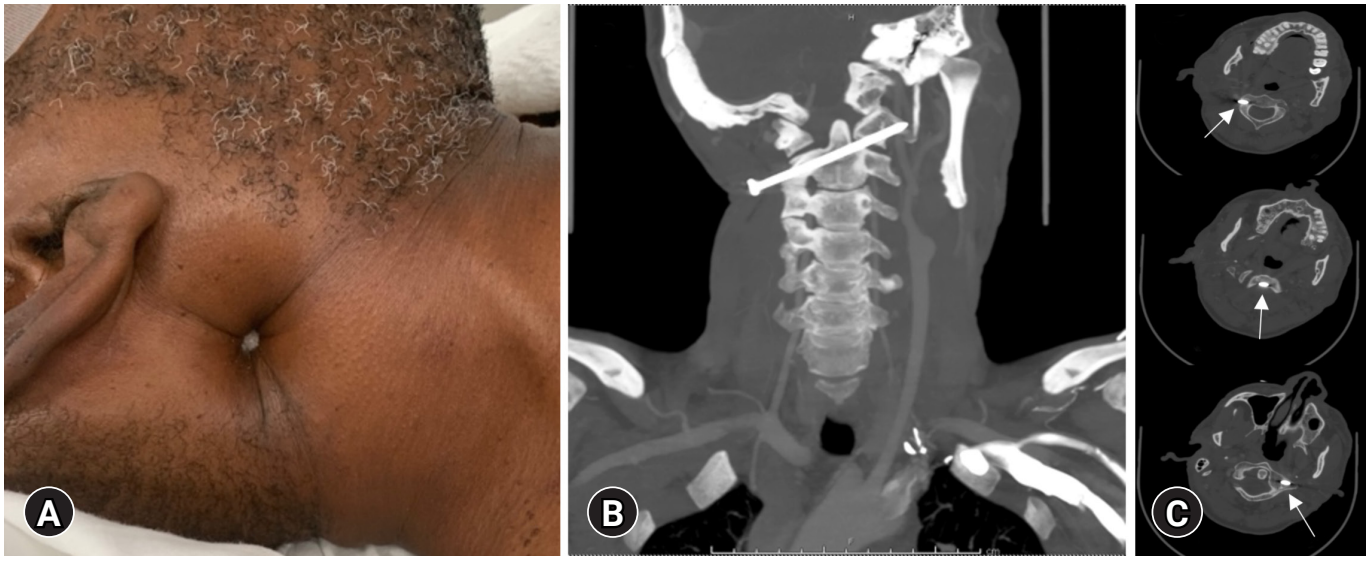


**Fig. 1.** Initial nail localization. (A) Entry site of the projectile, with significant depression of surrounding tissues, in the right superior neck below the level of the mastoid process. (B) Coronal cervical computed tomography angiography image demonstrating the trajectory of the projectile and involvement of both the right vertebral artery and the C2 vertebral body. (C) The projectile nail (arrows) impinged upon the right vertebral artery and traversed the C1–C2 facet to enter the lateral mass and transverse process of C1.

ma formation in the area. The patient reported occasionally taking 325 mg of aspirin.

The initial history and physical assessment were immediately followed by diagnostic imaging to better understand the extent of the injury and potential neurovascular structure involvement. Computed tomography (CT) of the head and CT/CT angiography of the neck were performed, revealing an approximately 3-inch-long nonbarbed nail entering the right C2 transverse process and penetrating the right transverse foramen, producing a grade IV vertebral artery injury. Occlusion of distal flow was seen in the V3 segment of the right vertebral artery, with distal reconstitution just above the nail from collateral supply (Fig. 1B). No notable hematoma was observed surrounding the affected vertebral artery. The nail traversed the C2 vertebral body, left C1–C2 facet, and C1 lateral mass and terminated in the left C1 transverse process (Fig. 1C). Additionally, an acute right C7 transverse process fracture was present. Head CT revealed no acute cranial or intracranial abnormalities including, but not limited to, cranial fractures or intracranial hemorrhage. The patient's tetanus vaccination status was reviewed, and no antibiotics were given. In this case, the decision was made to remove the projectile to improve range of motion and reduce infection risk.

## Operation

General anesthesia was induced with propofol, midazolam, fentanyl, rocuronium and succinylcholine, and local anesthesia with lidocaine. Prior to removal of the nail, coiling of the right vertebral artery was performed. First, the femoral artery was catheterized with subsequent diagnostic angiography of the bilateral vertebral arteries and common carotid arteries (Fig. 2A). The right vertebral artery demonstrated good opacification with notable stenosis and dissection at the point of injury; distal flow was noted to be quite slow, but appreciable washout from the occipital artery was present (Fig. 2B). The left common carotid artery was not visualized during the procedure. Complete patency of the left vertebral artery was observed, without discernible vessel wall dissection or impingement. Of note, the right occipital artery was found to anastomose with the posterior circulation.

Coiling of the right vertebral artery was performed both distal and proximal to the nail to prevent hemorrhage (Fig. 2C). Access via the right vertebral artery allowed an SL-10 microcatheter (Stryker Neurovascular, Fremont, CA, USA) to be advanced around the nail and to be coiled from the distal V3 back to the distal V2 segment with detachable platinum coils (Target XL, Stryker Neurovascular). Subsequently, the nail was removed using a vice grip with an attached slap hammer (Fig. 3). The right vertebral artery was then immediately revisualized, demonstrating residual distal flow. This prompted additional coil placement to completely occlude distal flow (Fig. 4A).

## Postoperative course

The patient tolerated the procedure well and displayed no post-


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**Fig. 2.** Digital subtraction angiography prior to embolization and postembolization. (A) Preserved flow within the right common carotid artery. (B) Diagnostic angiography of the right vertebral artery demonstrating diminished flow distal to the nail. X1 and X2 denote the vessel diameter proximal and distal, respectively, to the region of diminished flow. (C) Coil placement proximal and distal to the nail in the right vertebral artery prior to nail removal.

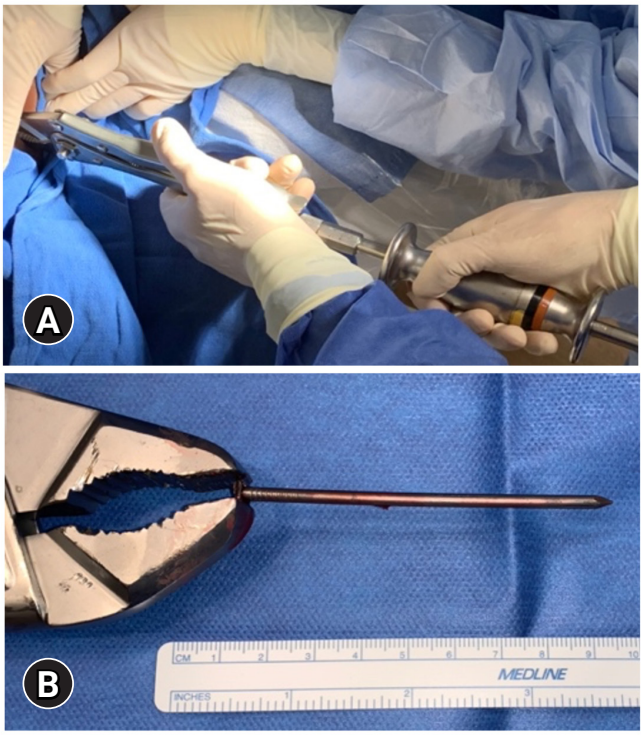


**Fig. 3.** Postembolization nail removal. (A) Vice grip attached to a slap hammer for removal of the nail. (B) Intact, removed nonbarbed nail.

operative neurologic deficits. Postoperative magnetic resonance imaging (MRI) scans of the brain and cervical spine showed no evidence of stroke or spinal cord injury. After discharge on postoperative day 2, the patient was instructed to take 81 mg of aspirin once daily and follow-up in 4 weeks.

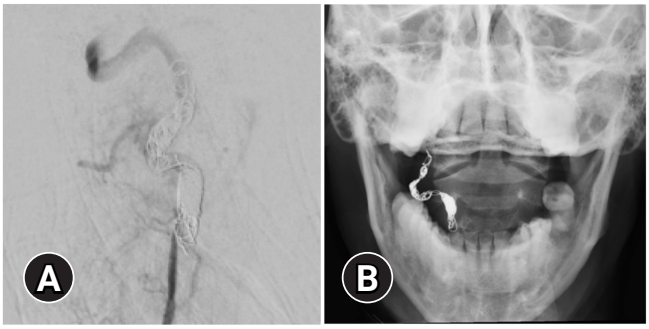


**Fig. 4.** Postembolization follow-up. (A) Confirmed occlusion of the right vertebral artery after repeat embolization. (B) Outpatient follow-up cervical X-ray indicating an unchanged position of embolization coils within the vessel.

At the follow-up appointment, the patient had no acute complaints other than some slight discomfort with neck rotation to the left. A neurological exam yielded no concerns regarding muscle weakness in any of the extremities. Upright and flexion-extension cervical spine X-rays, as well as cervical CT angiography, indicated no change in vertebral alignment and no altered positioning of the embolization coils in the right vertebral artery (Fig. 4B).

Informed consent for publication of the research details and clinical images were obtained via general treatment consent.

## DISCUSSION

Vertebral artery involvement is highly uncommon in patients with penetrating trauma, estimated at 0.5% of all cases [7]. The vertebral artery is relatively more likely to be affected in cases of blunt injury to the cervical spine or hyperextension of the neck with lateral flexion. The anatomic course of the vertebral arteries through the transverse foramina of the cervical vertebrae makes the management of patients with penetrating injuries quite intricate. In such cases, it is crucial to quickly assess the extent of vascular involvement through techniques such as CT angiography. Blind disturbance of the embedded projectile could lead to significant bleeding that would be quite difficult to manage, even surgically, as proximal and distal control of the vertebral arteries is challenging to achieve. Additionally, initial imaging can help assess the type of nail(s) embedded in the tissue, as the presence of a barbed nail or a nail with a washer could alter the treatment approach [8].

Once the initial imaging evaluation has been completed, secondary imaging to be performed includes diagnostic angiography, which allows a more focused assessment of the treatment approach. For a penetrating injury threatening a high cervical portion of the vertebral artery, an endovascular approach is the most appropriate. Numerous articles have highlighted the safety and effectiveness of endovascular embolization in treating grade I to grade V vertebral artery injuries, whether iatrogenic or trauma-induced [9–11]. Embolization proximal and distal to the site of injury is the recommended method, as it minimizes potential bleeding as the foreign object is extracted. This approach is ideal for nail penetration injuries, as the nail can be regarded as a low-velocity projectile. Thus, tissue damage is localized along the trajectory of the nail, unlike with a high-velocity projectile such as a bullet, which causes extensive damage to surrounding tissue due to cavitation [12,13]. Final assessment of vessel embolization also remains important; another case series discussing endovascular treatment of vertebral artery injuries saw only an 89% rate of immediate total occlusion [9]. Notably, the reliance on interventional radiology for treating penetrating vertebral artery injuries requires a facility with the necessary equipment. When a penetrating vertebral artery injury occurs in a rural setting, the extent of the injury must be assessed to determine patient stability for transport to a tertiary care center. Surgical treatment of a penetrating vertebral artery injury is possible and has been documented, but this has generally been reserved for cases involving uncontrolled bleeding, suspected spinal cord injury, or vertebral instability [8,14].

When pursuing endovascular rather than surgical treatment for a penetrating injury, particularly with bony involvement as in the present case, assessing the stability of the cervical spine after removal of the foreign object is also of extreme importance. The cervical spine is much more susceptible to biomechanical instability than the thoracic spine, and extra precautions must therefore be taken in cases of projectile injuries. Thus, we obtained postoperative upright cervical spine X-rays to ensure general spinal stability. If possible, an MRI scan should also be obtained for a more precise examination of the stabilizing ligaments in the cervical spine. In particular, the atlantooccipital junction and atlantoaxial joints should be localized, as these are regions at high risk of injury in cases like the present one.

Finally, when dealing with uncommon mechanisms of purportedly accidental injury, the shape of the penetrating nail can hint at a potential cause, with bent nails suggesting a ricochet. In contrast, injuries involving straight nails, as in the present case, could result from a non-accidental or an accidental discharge. The location of the injury can also suggest a primary mechanism; upper extremity injuries are most likely to be due to accidents, while cranial/intracranial, cervical, or abdominal involvement is much more likely in cases of attempted self-harm [15]. An injury side corresponding with patient handedness may also increase the suspicion of self-harm. Cervical nail gun injuries appear to be quite a rarity in the published literature, and thus, little can be deduced from the location of the injury in the present circumstance. Detailed history taking and, if possible, cross-referencing with witnesses may be the only tools available to discern cause.

Cervical nail gun injuries are uncommon in the literature, particularly cases in which the projectile threatens a vertebral artery. Here, we present a case of such an injury, adding to the evidence suggesting that vertebral artery embolization prior to foreign body removal is a safe approach to treating nail gun-related injuries to the vertebral artery. In addition, we stress the importance of assessing the mechanical stability of the cervical spine via both upright cervical X-ray and cervical MRI postoperatively.

## NOTES

### Ethical statements

Informed consent for publication of the research details and clinical images were obtained via general treatment consent.

### Conflicts of interest

The authors have no conflicts of interest to declare.


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## Author contributions

Conceptualization: BNB; Data curation: SM; Project administration: BNB; Visualization: AC, SM; Writing–original draft: AC; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

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