

Retained Bullet in the Spinal Canal and Vertebral Artery Transection

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Background	A gunshot wound to the neck often leads to devastating damage. The initial management of the unstable patient is critical to survival, including resuscitation and control of bleeding, which is included in the Advanced Trauma Life Support (ATLS) protocol. This is a case report of a gunshot wound to zone II of the neck with vertebral artery transection, cervical vertebra fractures, and spinal cord transection.
Summary	A 46-year-old man presented to the trauma bay after a gunshot wound to the posterior neck with active hemorrhage and hemodynamic instability. He was taken emergently to the operating room. The intraoperative evaluation revealed damage to the right vertebral artery, which was controlled with clipping and local hemostatic agents. Following operative intervention and hemostasis, the patient was taken to interventional radiology for angiography and right vertebral artery embolization. Subsequent imaging demonstrated the presence of the retained bullet inside the cervical spine canal at the level of C6 with transection of the spinal cord. The bullet remained in place due to a risk of further neurologic damage during a retrieval procedure. The patient's spine was stabilized with fixation, and he survived with quadriplegia American Spinal Injury Association (ASIA) class A at C4.
Conclusion	Hemorrhage after a penetrating neck injury with vertebral artery damage and transection of the cervical spinal cord is a challenging scenario that requires immediate surgical intervention for bleeding control. We present a case report of a penetrating neck injury with a devastating neurological complication. The patient survived what is often a lethal injury and was discharged from the hospital to spinal rehabilitation.
Key Words	vertebral artery injury; spinal cord injury

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Case Description

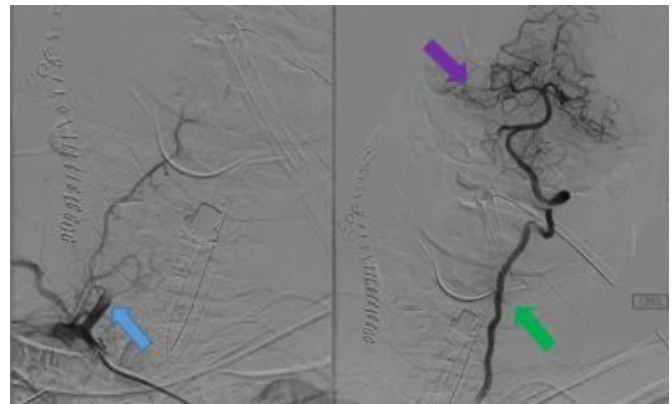
A 46-year-old man presented to the trauma bay after a gunshot wound (GSW) to the right neck. The patient arrested at the scene and received two minutes of CPR with a return of spontaneous circulation. He was intubated and transferred by air to our Level I Trauma Center. The primary survey on arrival demonstrated his endotracheal (ET) tube was in an appropriate position, breath sounds were equal bilaterally, and he was hemodynamically unstable. He had an active hemorrhage coming from a right-sided neck wound. His Glasgow coma score (GCS) was 3T after a dose of rocuronium for biting the ET tube. After full exposure, a zone II neck wound was identified.

A chest X ray was obtained as an adjunct to the primary survey in the trauma bay, revealing a foreign body in the middle of the neck. Due to the location of the injury, hypotension with ongoing bleeding, and an expanding neck hematoma, the patient was taken for operative neck exploration. A sterile Foley catheter was inserted in the small deep wound and inflated to achieve temporary tamponade. A massive transfusion protocol was simultaneously initiated. Operative exploration began with a curvilinear incision from the angle of the mandible to the sternal notch and medial to the sternocleidomastoid (SCM). Dissection continued down to the carotid sheath with lateral retraction of the SCM. The carotid sheath was opened, and the carotid artery, including its branches and the internal jugular vein, was evaluated—no injuries were identified.

During exploration, the patient had persistent desaturations and remained hypotensive, and bilateral chest tubes were placed with no hemothorax or pneumothorax appreciated. Our operative exploration continued with a posterior extension of the primary incision to evaluate the posterior triangle of the right neck, where active hemorrhage was appreciated. Intermittent occlusion by a balloon catheter was used during dissection, and local hemostatic packing agents were applied after further localizing bleeding. Dissection was carried to the cervical spine, which appeared to be disrupted at this level. The proximal and distal ends of what appeared to be the transected right vertebral artery were identified and clipped. Bone wax and oxidized cellulose-based hemostatic agent were used, achieving hemostasis. The patient was hemodynamically stable at this time, and the decision was made to proceed to interventional radiology for angiography and possible embolization. The wound was temporarily packed and

closed with staples. The angiography demonstrated a right vertebral artery dominant pattern with occlusion of its proximal end consistent with our surgical clip placement. The patient's left vertebral artery and posterior circulation were intact, including the right posterior inferior cerebellar artery. The proximal end of the right vertebral artery was embolized. The clips were adequately occluding the distal end of the vertebral artery (Figure 1).

Figure 1. Angiogram of Bilateral Vertebral Arteries (VA). Published with Permission



Right VA angiogram with proximal cut-off and subsequent embolization (blue arrow). Left VA angiogram without injury (green arrow) and intact circle of Willis (purple arrow).

Post-angiography and embolization, the patient was sent for a computer tomography (CT) scan for completion imaging. The radiopaque bullet appeared to occupy most of the spinal canal at the level of C6. Fractures were appreciated at C6 with a comminuted fracture of the vertebral body, C7 with a non-displaced fracture of the vertebral body, and C4/C5 with a fracture of the right transverse processes and foramen (Figure 2).

The patient returned to the operating room for re-evaluation and definitive closure of his neck incision. Due to the location of the patient's injury, an intraoperative upper endoscopy was done for esophagus evaluation, and no injury was identified. On postoperative day 1, the patient's neurologic evaluation revealed he had quadriplegia at the level of C5-C7. He was able to open his eyes and respond to questions appropriately.

Figure 2. Radiopaque Bullet Occupying Most of Spinal Canal at C6 Level. Published with Permission

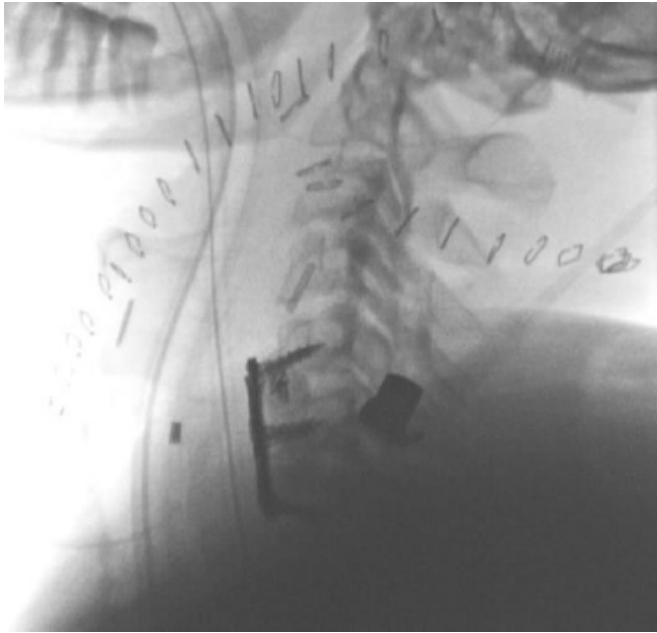


C7 non-displaced fracture, extensive comminuted fracture of C6 vertebra, and fracture of right lateral aspect of C5 vertebra involving C4 right transverse process and foramen.

The patient required blood, intravenous fluids, and vasopressors to maintain hemodynamic stability in the settings of acute hemorrhagic and neurogenic shock. He was maintained on ventilator support for the next few days with subsequent clinical stabilization and surgical fixation of

his cervical spine by neurosurgery on postoperative day 4 using an anterior approach (Figure 3). The decision was made to leave the retained bullet to minimize potential damage during retrieval.

Figure 3. Stabilization of Cervical Spine. Published with Permission



Due to persistent ventilator needs and the need for enteral access, a tracheostomy and a percutaneous endoscopic gastrostomy were performed on postoperative day 11 from the initial presentation. The patient's clinical course was complicated by diarrhea, confirmed to be *C. difficile*, which was treated with enteral vancomycin. He was additionally treated with a course of antibiotics for a urinary tract infection. The patient was ultimately discharged to spinal rehabilitation with an ASIA Class A injury at C4.

Discussion

Cervical spine GSW injuries often lead to poor prognosis and survival. About 70% of cervical wounds have complete neurological deficits.¹ The initial management of unstable patients is almost universal and follows the ATLS protocol, which includes resuscitation and control of bleeding. The combination of cervical spine trauma with vertebral artery injury is characterized by significant morbidity and mortality.² Profuse bleeding from the wound raises suspicion of a vascular injury. Vertebral artery injuries due to penetrating trauma are often asymptomatic and found during the exploration of a penetrating neck injury. The majority of cases are related to GSWs, and the most common anatomic segment of injury is V2 entering through the foramen transversi, C6 to C2.

Hemorrhage is usually associated with the involvement of carotid or jugular injuries. A vertebral artery injury may present as an exsanguinating hemorrhage that is difficult to control due to complex anatomy, challenging surgical exposure, and bleeding from adjacent structures.³ Surgical intervention usually leads to hemorrhage control by ligating the injured vertebral artery using sutures and/or clips.

Angioembolization is a preferable alternative in more stable patients that combines diagnostic and therapeutic means. Nevertheless, knowledge of an open technique to expose the vertebral artery is a required skill in the armamentarium of a trauma surgeon. Usually, the extended neck should be rotated slightly away from the side of the injury since an extensive turn can occlude the vertebral artery on the other side. The sternocleidomastoid incision is a standard trauma neck exploration that is useful for exploring vertebral arteries V1 and V2. This incision is made anterior to the SCM muscle from the mastoid process to the suprasternal notch.

After exploring and retracting the carotid sheath and its content medially, the anterior scalene muscle should be lateralized or even transected for better exposure with caution for potential phrenic nerve damage. This can help with a proximal ligation of VA. During exposure of V2, some authors recommend incising the prevertebral fascia or anterior longitudinal ligament for better dissection from the prevertebral muscles.^{4,5} In our case, because of obviously fractured vertebrae, we did not unroof the vertebral canal and managed to control the bleeding using bone wax and stapling the proximal and distal ends of the vertebral artery. In case of limited visualization, there is a high risk of cervical nerve root damage related to blind stapling and packing with bone wax.⁶ The vertebral artery should be occluded both proximal and distal to the injury due to potential backflow. The assessment of the larynx and esophagus must be completed on a non-emergent basis.

GSWs cause direct (bullet or broken bones) and indirect (blast or cavitation wave) injuries. This case report is unique due to the combination of two major injuries: a vertebral artery with hemorrhagic shock and a high spinal cord transection with neurogenic shock. The extent of damage and ultimate prognosis usually remain obscure until initial steps are accomplished. The controversy in management becomes obvious later and depends on the bullet's trajectory in the body and its final location. In the case of our patient, the bullet was retained in the spinal canal at the level of C6.

Immediate spine immobilization with a hard C-collar is required until the completion of imaging and further steps are attempted based on the existing algorithms for GSWs to the spine.^{7,8} In the case of complete or incomplete neurological deficits at the cervical or thoracic spine level, operative decompression does not always provide benefit. It can lead to complications, making non-surgical management preferred.⁸⁻¹⁰ The removal of a bullet from the spinal canal has been described in the absence of neurologic deficits; however, not in the case of high injury with complete cord transection.¹¹

High cervical spine injuries above the level of C6 are at risk for breathing impairment due to diaphragm dysfunction; however, it is hard to predict the actual level of spinal cord damage at the initial injury. Considering a lodged bullet in a vertebral canal and neurological deficits from a complete cord transection, the bullet was left in place to avoid further worsening of neurology. Stabilization of the spinal cord was accomplished later due to additional fractures of the spinal vertebrae, as there was a concern that the injury location was too high and some vital functions like breathing would be at risk without spine stabilization. The biggest concern, in this case, was edema in the still viable spinal cord above the level of the bullet.

It is vital to assess the patient neurologically and discuss management details based on the imaging findings and the extent of neurological deficits with a patient and family. Thorough interdisciplinary communication with the family is important for a clear understanding of prognosis and complications. In this case, the patient survived with significant neurological deficits. He was able to communicate with his family members and medical staff. The patient was discharged to spinal rehabilitation with quadriplegia.

Conclusion

This is an original case report of a GSW to the neck with vertebral artery damage and a bullet lodged in the cervical spinal canal. Despite catastrophic neck injury and devastating neurological complications, the patient survived to discharge from the hospital to spinal rehabilitation.

Lessons Learned

The management of complex GSWs to the neck with neuro-vascular injuries and comminuted vertebra fractures should be initially adherent to ATLS protocol. Hemorrhagic and neurogenic shocks can present simultaneously and complicate treatment. A transected vertebral artery

with bleeding can be complex to access surgically but should be attempted in an unstable patient when bleeding from the carotid sheath is excluded. Non-operative management of a retained bullet in the cervical spinal canal is a viable option after stabilization of the cervical spine.

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