

# Management of a penetrating injury to the carotid artery

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## HISTORY

A 59-year-old man presented to the trauma center with multiple stab wounds to his face, neck, chest, abdomen, bilateral arms, and bilateral hands. He did not complain of pain in any specific area of injury.

## EXAMINATION

The patient was able to state his name. His systolic blood pressure was 98 mmHg, heart rate was 107 beats/min, and respiratory rate was 34 breaths/min with audible breath sounds bilaterally. There was a main 1.5 cm stab wound to his left neck posterior to the sternocleidomastoid muscle at the level of the thyroid cartilage. No air was bubbling out of this nor any of his other cervical wounds. In addition, there was no associated bleeding, hematoma, palpable thrill, or audible bruit. His neurologic examination revealed that his Glasgow Coma Scale score was 15, and he did not have any lateralizing signs or focal deficits. His cranial nerve examination was intact. On abdominal examination, he did not have tenderness in all four quadrants, but did not have peritonitis. His pulse examination was normal in all four extremities.

## QUESTION

Which clinical finding would NOT warrant immediate exploration in the operating room?

- Positive focused abdominal sonogram for trauma (FAST) with hypotension
- Pulsatile bleeding from the neck wound
- Peritonitis on abdominal examination
- Crepitus on chest palpation

## MANAGEMENT

After blood was drawn for type and cross-match, two large bore intravenous catheters were inserted. A chest X-ray and an extended focused abdominal sonogram for trauma (eFAST) examination were performed. The chest X-ray did not show any abnormalities, and the eFAST was negative.

The patient's repeat systolic blood pressure was 113 mm Hg. Because he had a normal blood pressure, did not have hard signs of a vascular or aerodigestive injury in his neck, and did not have a positive FAST nor peritonitis on abdominal examination, he underwent a CT scan of his abdomen and pelvis with contrast as well as a CT angiogram of his head and neck. The abdominal CT showed an American Association for the Surgery of Trauma Organ Injury Scale grade IV splenic injury and wound trajectories concerning for several diaphragmatic injuries. In addition, he had an intramural hematoma and

circumferential intimal flap projecting into the lumen of the left common carotid artery just proximal to the carotid bifurcation (figure 1). There was no evidence of active extravasation from the common carotid artery, and the circle of Willis was intact.

## QUESTION

What would your treatment be for the injury to the common carotid artery?

- Observation, serial neurologic examinations
- Endovascular stent-graft placement
- Cervical exploration via anterior sternocleidomastoid incision
- Cervical exploration via collar incision

## MANAGEMENT

The patient was taken to the operating room for an exploratory laparotomy, esophageal endoscopy, bronchoscopy, and cervical exploration. At the exploratory laparotomy, a splenectomy, left phrenorrhaphy x3, and closure of anterior and posterior gastric lacerations were performed. The esophageal endoscopy and bronchoscopy did not reveal any upper aerodigestive tract injuries.

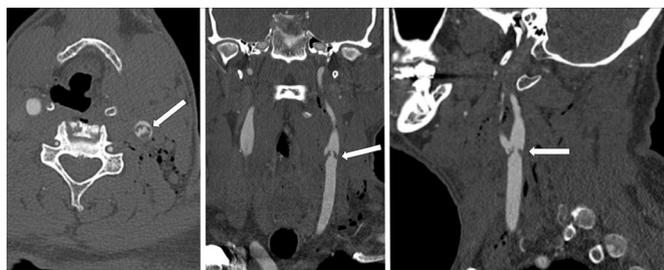
He was then repositioned with both arms tucked, in a beach chair position, with his head turned to the right side. The neck was prepared and draped to include the manubrium, the angle of the mandible, and the ipsilateral ear lobe within the surgical field. A longitudinal skin incision was made overlying the anterior border of the left sternocleidomastoid muscle. The sternocleidomastoid muscle was retracted laterally, and the internal jugular vein was identified. Dissection along the medial border of the jugular vein led to the facial vein, which was ligated using 3-0 silk ties and then transected. The jugular vein was retracted laterally. Of note, there was minimal hematoma and no active bleeding encountered in the dissection. The common carotid, internal carotid, external carotid, and superior thyroid arteries were exposed. A 5 mm area of bruising on the anterolateral surface of the left common carotid artery approximately 2.5 cm proximal to the carotid bifurcation was visualized. In the middle of this area of bruising was a pinpoint hole in the adventitia of the artery.

Unfractionated heparin (100 units/kg) was administered intravenously and allowed to circulate for 5 minutes. The internal carotid artery was then clamped followed by the common carotid artery and then the external carotid artery. The superior thyroid artery was controlled with a silk suture. During the time that the vasculature was clamped,

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**Figure 1** CT angiogram of the neck (axial, coronal, and sagittal views) showing a flow limiting circumferential intimal flap projecting into the lumen of the left common carotid artery just proximal to the carotid bifurcation.

the mean arterial pressure was maintained at >75 mmHg. An arteriotomy centered on the area of bruising was made on the common carotid artery using a scalpel with a #11 blade. Potts scissors were used to extend the arteriotomy onto the internal carotid artery. There was a circumferentially elevated intimal flap that had been caused by the stab wound. This was raised using a Freer elevator. The intima was transected distally just proximal to the carotid bifurcation, and this portion of intima was excised. The endarterectomized surface was gently irrigated with heparinized saline to remove all free debris. Interrupted 6-0 prolene sutures were then placed to circumferentially tack down the intima with the knots on the outside of the vessel. The arteriotomy was then partially closed using a bovine patch and a continuous suture. Prior to tying down the last suture, the internal carotid artery was backbled and re-clamped, the common carotid artery was flushed externally and re-clamped, and the external carotid artery was backbled and re-clamped. Flow was then re-established by unclamping the external carotid artery, the common carotid artery, and, lastly, the internal carotid artery while tying down the last suture. The suture line was checked for hemostasis, and bleeding from needle holes was controlled with Surgicel (Ethicon, Raritan, NJ). The wound was closed in layers using 3-0 vicryl sutures for the platysma and deep dermal layers and a 4-0 monocryl suture for the skin.

At the end of the operation, the patient was left intubated, but awakened to do a neurological examination. He was able to follow commands and move his upper and lower extremities bilaterally. In addition, he was able to raise his eyebrows, stick out his tongue, and show his teeth indicating that his cranial nerves were intact. Postoperatively, the patient was started on aspirin 81 mg daily.

## DISCUSSION

### Epidemiology

Penetrating wounds to the neck are common in the civilian trauma population. Approximately 35% to 50% of patients with a cervical injury caused by a gunshot wound have significant injuries, while only 10% to 20% of patients with a stab wound do.<sup>12</sup> In a study evaluating 3911 patients in the National Trauma Data Bank with penetrating wounds to the common carotid or internal carotid artery, the majority of patients were men (86%) and most injuries were due to gunshot (66.3%) and stab wounds (31.8%). The main associated injuries in the neck were to the internal jugular vein (24.5%), cervical spine (18.5%), larynx (7.2%), external carotid artery (6.2%), vertebral artery (5.5%), pharynx (4.8%), and vagus nerve (0.8%).<sup>3</sup>

### Zones of the neck

The zones of the neck were first described by Monson *et al.* from Cook County Hospital in 1969.<sup>4</sup> The definitions of the zones were slightly redefined in 1979 as follows<sup>5</sup>:

Zone I: Sternal notch to cricoid cartilage.

Zone II: Cricoid cartilage to angle of the mandible.

Zone III: Superior to angle of the mandible.

The zones of the neck describe accessibility to vascular and other structures and aid in the choice of surgical approach. Zone I contains the origin of the common carotid artery, subclavian vessels, vertebral artery, innominate vessels, trachea, esophagus, apex of the lung, thoracic duct, and brachial plexus. Zone I structures are protected by the bony thoracic inlet, and, thus, exposure is difficult and requires a median sternotomy, high anterolateral thoracotomy, or a supraclavicular incision for proximal control of the subclavian artery.

Zone II contains the bifurcation of the common carotid artery, vertebral artery, internal jugular vein, esophagus, and trachea. These structures are relatively easy to gain exposure to via an anterior sternocleidomastoid or collar incision.

Finally, zone III structures include the distal internal carotid and vertebral arteries, cranial nerves, and the pharynx. Zone III is the most difficult to expose surgically. Approaches include sublaxation of the temporomandibular joint and interdental wiring, vertical ramus mandibular osteotomy, or the use of endovascular techniques such as embolization or stent-graft placement.<sup>6,7</sup>

### Management of carotid artery injuries

During World War II, cervical exploration was mandatory when the platysma muscle was violated. Management of civilian penetrating neck injuries has evolved tremendously since then to an approach of selective operative management.<sup>2,3</sup>

Patients who present with “hard signs” of vascular injury such as external hemorrhage, internal hemorrhage into the trachea, esophagus, or mouth, evidence of a pulsatile or expanding hematoma in the neck, acute neurological symptoms, tracheal deviation, or elevation of the floor of the mouth from a hematoma require prompt operative intervention.<sup>6,8</sup>

Prior to moving the patient to the operating room, it is important to secure the airway as it is at high risk if there is a rapidly expanding hematoma, intraoral bleeding, or bleeding into the trachea or esophagus. External or internal hemorrhage is controlled with manual pressure, pressure with gauze packing, or Foley or Fogarty balloon placement for tamponade.<sup>6</sup>

Depending on the character and size of the arterial injury, one may consider lateral arteriorrhaphy, angioplasty with vein or prosthetic patch, segmental resection and end-to-end anastomosis or insertion of a saphenous vein, allograft, or polytetrafluoroethylene interposition graft, or transposition of the external carotid artery to replace the proximal internal carotid artery.<sup>3,7</sup> On the rarest of occasions, ligation can be considered if surgical repair cannot be performed (ie, destructive injury to internal carotid artery at base of skull). If a patient is found to have intimal disruption and/or thrombosis, an endarterectomy±thrombectomy should be performed.

In patients with hemodynamic stability and no obvious signs of arterial or venous injury, workup with CT arteriography, duplex ultrasonography, or color flow duplex is warranted.<sup>2</sup> Disruption to intimal flow from an intramural hematoma or intimal flap, a traumatic false aneurysm, or a carotid-jugular fistula require intervention. The approach to operative intervention will depend on the zone of injury as discussed above.

Postoperatively, it is important to monitor the patient's neurologic examination. If there are any changes within the first 24 hours, prompt reimaging to determine the cause is necessary.

### Placement of a temporary intraluminal shunt during arterial repair

Shunting is usually not needed when managing injuries to the carotid artery in the neck as long as the clamp time is <30 min and there is vigorous back-bleeding from the cerebral end of the vessel.

### Clamping of vessels

Once the common, internal, and external carotid arteries are isolated, the order of clamping and unclamping vessels is very important to ensure that no atheromatous debris enters the cerebral circulation. When clamping, use the mnemonic *ICE*—first clamp the internal, then the common, and, lastly, the external carotid artery. With the internal carotid artery clamped first, any debris from clamping the common carotid gets diverted to the external carotid artery. When unclamping the vessels, release clamps following the reverse order of the mnemonic: *ECI*. Once the external and common carotid vessels are unclamped, wait 10–15 s before restoring flow to the internal carotid artery.

### Administration of unfractionated heparin

The surgeon should consider administering heparin intravenously at a dose of 100 units/kg prior to clamping the carotid artery in all patients, but especially if a prolonged (segmental resection and interposition graft) or difficult repair (near base of skull) is anticipated. If the patient has other major injuries, heparin can be omitted.

### CONCLUSION

When a patient presents with “hard signs” of a cervical vascular injury other than a carotid-jugular arteriovenous fistula,

immediate operative intervention is imperative. In patients who are hemodynamically stable with proximity of a penetrating wound or “soft signs” only, further workup with an initial CT arteriogram of the neck is warranted including after shotgun wounds with a wide distribution of pellets.

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