

Overview of Endovascular Management of Traumatic Carotid Lesions

Determining appropriate intervention based on lesion severity and patient characteristics.

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Traumatic extracranial carotid lesions can result from blunt, penetrating, or iatrogenic injuries. Blunt cerebrovascular injuries are found in up to 0.1% of all patients hospitalized for trauma in the United States, but the incidence can be as high as 2.7% in patients with an Injury Severity Score > 16.¹ Of note, blunt lesions are associated with neurologic morbidity up to 80% and mortality as high as 40%. Penetrating injuries to the carotid artery occur in up to 10% of all cases of penetrating neck trauma² and are also associated with a high mortality rate (50%).³ Finally, iatrogenic carotid injuries, in most cases, are associated with misplacement of central venous lines with an incidence of 0.1% to 0.8%.⁴

Management of extracranial carotid lesions varies from medical therapy to endovascular or open repair, depending on the severity of the lesion and the patient's overall clinical status. Endovascular repair has gained more acceptance given its decreased invasiveness, safety, and effectiveness.

DIAGNOSIS AND SCREENING

For penetrating and iatrogenic lesions, diagnosis is straightforward. Patients undergo prompt radiologic evaluations with chest radiography and CT angiography (CTA) of the neck as part of established protocols.³ In case of inadvertent arterial puncture, the course of the central venous line follows the aortic arch and descending thoracic aorta, instead of overlying the right atrium (Figure 1).

After blunt trauma, CTA of the neck is performed in every patient with neurologic symptoms unexplained by known injury or in patients presenting with epistaxis from a suspected arterial source. Due to the high morbidity and mortality of cerebrovascular trauma,

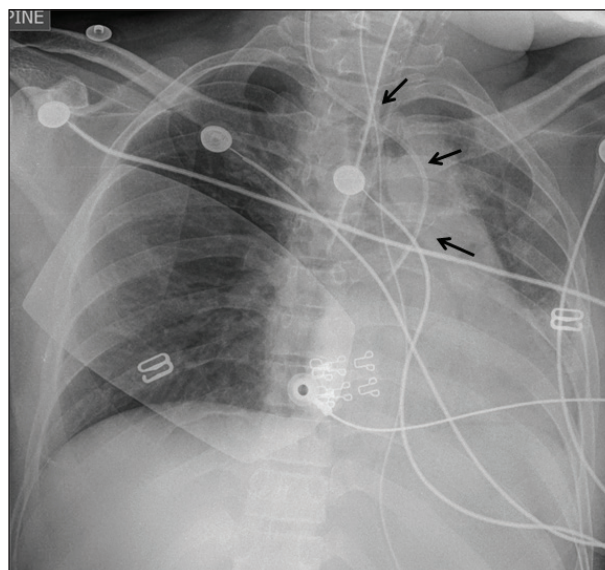


Figure 1. Chest radiograph post–central line insertion shows a catheter following the trajectory of the aortic arch and descending thoracic aorta (black arrows).

screening of asymptomatic, high-risk patients has been proposed, including patients with Glasgow Coma Scale score < 8, petrous bone fracture, diffuse axonal injury, cervical spine fracture, and Lefort II or III facial fractures.^{1,5} Digital subtraction angiography (DSA) is still the gold standard for diagnosis; however, multidetector CTA has been used as a screening and diagnostic modality in most institutions, given its noninvasiveness, widespread availability, and acceptable sensitivity and specificity.^{6,7} The injuries can be identified as intimal irregularities, dissection, transection with or without contrast extravasation, pseudoaneurysm, and arteriovenous fistula involving the common, internal, and

TABLE 1. VASCULAR INJURIES GRADING SYSTEM

Grade 1	Intimal irregularity with < 25% narrowing
Grade 2	Dissection/intramural hematoma with > 25% narrowing
Grade 3	Pseudoaneurysm
Grade 4	Occlusion
Grade 5	Transection with extravasation

external carotid arteries and their branches. Biffi and colleagues have proposed a grading system to stratify lesions and guide treatment strategy (Table 1).⁸

Recently, the use of optical coherence tomography (OCT) has been described in the evaluation of traumatic carotid aneurysm.⁹ Two reported cases demonstrated disruption of the intima, and only stretching of the media and adventitia were identified, as opposed to full-thickness vessel wall disruption, which was expected. Interestingly, in one case, OCT identified the presence of thrombus and additional focal dissection not seen on conventional DSA. In addition, OCT can better display stent apposition against vessel wall, which is critical for adequate sealing and long-term patency. Hence, it is expected that OCT will become a powerful tool to better understand traumatic injury pathophysiology, identify its extension and severity, and define appropriate therapy.

ENDOVASCULAR MANAGEMENT

A surgical approach in this setting can be associated with increased morbidity and mortality related to massive hemorrhage, cranial nerve injury, and stroke. In addition, patients are often clinically unstable due to injury in another organ(s) and are not candidates for conventional surgery. In this scenario, endovascular management has become the standard approach in many institutions, especially for grade II and III lesions resulting from blunt trauma.^{10,11} Grade IV lesions, in which the vessel is completely occluded, are more challenging for endovascular techniques, because crossing the lesion may take a long time or may not even be possible. However, Cohen and colleagues described 16 patients with severe stenosis (90%) or occlusion of the internal carotid artery that were successfully crossed utilizing a coaxial microcatheter and microwire.¹² Grade V lesions (transection with extravasation) are rarely treated by the endovascular approach, as those



Figure 2. Lateral view DSA of the left carotid artery after blunt trauma demonstrates intimal flap (white arrow) and smooth tapering of the lumen distally (black arrow) consistent with dissection (A). Post-stent placement DSA shows resolution of the intimal flap and reestablishment of the true lumen diameter (B).

patients are typically subject to immediate surgical exploration.

Although there is no specific grading system for penetrating and iatrogenic lesions, classification and management of these injuries can follow the same principle as blunt vascular trauma. Different techniques have been described to treat penetrating or iatrogenic lesions, including balloon occlusion, embolization, stenting, stent-assisted coil embolization, stent grafting, and percutaneous thrombin injection.¹³⁻¹⁶ Treatment strategy varies with the type of lesion (dissection vs pseudoaneurysm) and location.

Common Carotid and Extracranial Internal Carotid Arteries

Dissection. Flow-limiting dissection requires invasive treatment due to risk of stroke, and even non-flow-limiting lesions may require more aggressive therapy because they can lead to stroke. The goal of the endovascular approach is to seal the intimal entry point to avoid lesion expansion and compression of the false lumen, in order to increase true lumen diameter and allow for adequate brain perfusion. This can be achieved by placing a stent across the injury (Figure 2).

A meta-analysis that included 64 traumatic carotid dissections showed a technical success rate of 99%, procedural complication rate of 1.3%, and neurologic events in 1.4% of the patients,¹⁷ confirming that stenting is a safe and a technically feasible approach.

Bare-metal self-expandable stents are the preferred option to treat dissections. In the meta-analysis by Pham et al,¹⁷ the Wallstent (Boston Scientific

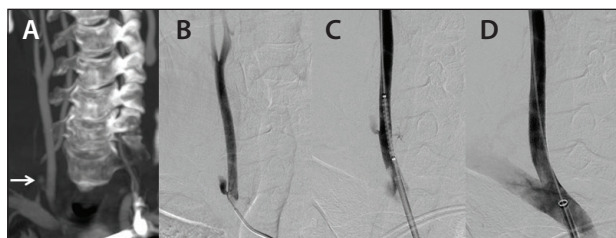


Figure 3. CTA of the neck with maximum-intensity projection reconstruction demonstrates pseudoaneurysm of the proximal right common carotid artery (white arrow) in a cirrhotic and coagulopathic patient. A central venous access was misplaced in the arterial system and inadvertently removed before correction of the coagulopathy. The patient developed a large neck hematoma (A). Selective DSA of the right common carotid artery confirmed a pseudoaneurysm originating from the lateral aspect of the proximal segment of the vessel (B). A 7-mm X 2.5-cm Viabahn stent was deployed across the vessel wall defect (C). Post-stenting DSA confirms satisfactory sealing of the vessel wall defect and successful exclusion of the pseudoaneurysm. Note the good apposition between the stent and vessel wall, which is critical to decrease the risk of stent thrombosis (D).

Corporation) was the most commonly used device, utilized in 58% of the cases, followed by SMART stents (Cordis Corporation), which were used in 18% of cases.

Pseudoaneurysm. Pseudoaneurysms (grade III lesions) are believed to originate from full-thickness vessel wall injury, resulting in a contained but partially perfused hematoma. For this reason, some techniques previously reported in the literature, including coiling or stent-assisted coil embolization, may not be effective because the source of bleeding is not addressed. In addition, different techniques such as balloon occlusion of the carotid artery could lead to low brain perfusion and may not be tolerated by the patient.

Therefore, stent grafting is now the preferred option for treatment of pseudoaneurysm, because the vessel wall defect can be effectively sealed by the endoprostheses, resulting in complete thrombosis of the pseudoaneurysm (Figure 3). In the early 1990s, experience with stent graft placement involved handmade devices composed of balloon-expandable stents covered by vein grafts. Later, manufactured devices became available, giving physicians much better options. Several reviews have shown a very good safety profile and satisfactory results with stent grafts.^{13,14,18} The types of stents described in the literature included both balloon- and self-expandable stents. It is now well known that balloon-expandable stents are not suited for the common and extracranial internal carotid arteries because

they are subjected to increased external compression, which can lead to strut damage and stent occlusion.

Our preference is to use covered self-expandable stents, which are more flexible and less likely to be damaged by external compression. The Viabahn stent (Gore & Associates), which is a polytetrafluoroethylene (PTFE)-covered nitinol self-expandable stent, is well suited for this purpose because the PTFE is nonporous and avoids type IV endoleak. This type of complication has been described with the polyethylene terephthalate-covered Wallgraft (Boston Scientific Corporation) stent, which has significant porosity¹⁴ and is no longer available. Important consideration needs to be made when treating lesions involving the carotid bifurcation, as there is potential risk of pseudoaneurysm recanalization through the external carotid artery (ECA). Therefore, coil embolization of the ECA is advisable to avoid type II endoleak (Figure 4).

Postprocedure antithrombotic strategy is crucial for long-term success because the rate of stent occlusion has been described to be much higher in this setting compared to atherosclerotic disease.¹⁹ Despite the high incidence, no specific protocol has been established for this purpose, and the strategy of dual antiplatelet therapy with clopidogrel and aspirin has been advocated based on the experience with atherosclerotic disease. Close follow-up should be performed, and again,



Figure 4. Large pseudoaneurysm involving the common carotid bifurcation. Note coil embolization of the ECA prior to stenting in order to avoid retrograde filling of the pseudoaneurysm.

no specific protocol has been developed so far, including time and image modality. A reasonable approach would be Doppler ultrasonography at 3, 6, and 12 months and then annually.

External Carotid Artery and Its Branches

Traumatic lesions of the ECA and its branches are usually represented by pseudoaneurysms, a result of vessel wall injury due to blunt, penetrating, or iatrogenic trauma. The diagnosis is based on history and clinical examination and confirmed by imaging, including ultrasonography, CT, MRI, and/or DSA. The facial artery is more prone to injury due to its tortuous course over the mandibular angle, masseter, and cheek.

Regardless of the size, lesions of the ECA need to be treated once diagnosis is made, as they can rapidly expand and cause stroke, nerve impingement, pain, and cosmetic disfigurement. Surgical exploration with ligation is considered the definitive treatment because hemostasis can be effectively achieved, and the mass effect is promptly resolved by evacuating the hematoma.

Endovascular management has gained an important role as technology improves and safety increases. It is a well-suited alternative for lesions that are not easily surgically accessible and in patients who prefer not to have a surgical scar for cosmetic reasons. Dolati et al reported 114 pseudoaneurysms treated with either an endovascular or a percutaneous approach.²⁰ Embolization was performed in most of the lesions treated endovascularly, utilizing different embolic agents. Coils were the most common agents (81.6%), followed by cyanoacrylate (4.5%). Other agents were Gelfoam (Pfizer, Inc.) and microparticles such as Embosphere (Merit Medical Systems) and polyvinyl alcohol (Cook Medical). Percutaneous thrombin injection was performed in 6.1% of the cases.

Given the rich collateral circulation of the ECA territory and small size of these branches, occlusion of the parent vessel is a safe and effective way to treat these pseudoaneurysms. Coil embolization was associated with the lowest complication rate (7.5%) among the embolic agents, while cyanoacrylate had the highest (50%). Most complications come from the innumerable anastomoses between the external and internal carotid arteries that can lead to nontarget embolization of intracranial branches, resulting in stroke or blindness. Therefore, 0.018-inch detachable coils delivered through a microcatheter represent an appropriate choice for this task.

CONCLUSION

Trauma to the carotid artery is associated with high morbidity and mortality but fortunately is not a common condition. Complications of unidentified lesions

can be devastating and efforts should be made to screen high-risk patients. An endovascular approach is a safe and effective alternative treatment when appropriate technique and devices are used. Postprocedure antiplatelet therapy and follow-up with Doppler ultrasound are critical to increase the likelihood of good long-term outcomes. ■

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