Subclavian Artery Trauma: Endovascular Management

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Richard C. Hershberger and Pratheek Kakkasseril

Content

The treatment of traumatic vascular injuries has evolved with endovascular therapy becoming an important tool to deal with these difficult and often complex injuries. The technical aspects of vascular exposure and repair in the setting of trauma are often more challenging than in other settings. Open surgical repair of traumatic arterial injury is often complicated by distorted anatomy secondary to associated hematomas or pseudoaneurysms. The exposure of the great vessels of the arch is associated with significant morbidity and mortality. Depending on the location, an open approach could require a median sternotomy, thoracotomy, and supraclavicular, infraclavicular, or clavicular transection.

Injuries to arteries of the thoracic outlet constitute 5–10 % of arterial trauma [1]. Reported morbidity and mortality ranges from 5 to 30 % [2]. Blunt thoracic outlet arterial injuries account for less than 5 % of all vascular injuries caused by blunt force trauma [3]. The incidence of penetrating injuries is 5 % for gunshot wounds and 2 % for stab injuries of the great vessels [4]. The overlying bony and muscular structure provides protection for these vessels, but when they do occur, they can present with life-threatening hemorrhage and critical limb ischemia.

More recently, injury to the subclavian artery appears to be more commonly addressed with endovascular techniques. A recent review of the literature discovered 38 articles describing 181 patients with subclavian artery injury treated with endovascular methods [5]. Compared with traditional surgical repair, endovascular stent graft repair of traumatic arterial transection has been associated with a decrease in anesthetic requirement, blood loss, operative time, fluid, and transfusion requirements [6].

The use of coils, bare metal, or covered stents allows the operator to avoid large incisions and significant fluid shifts in patients that often have a multitude of other issues due to their overall trauma burden. Coil embolization has been reserved for the treatment of small traumatic pseudoaneurysms and arteriovenous fistulas involving nonessential vascular territories. In the treatment of arterial dissection, bare metal stent placement over the dissection entry point serves to reapproximate the intima, preventing continued flow into

R.C. Hershberger, MD, RVT (✉)
P. Kakkasseril, MD
Department of Vascular and Endovascular Surgery, Loyola University Medical Center, 2160 S First Ave, EMS Building 110 Rm 3218, Maywood, IL 60153, USA

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the false vessel lumen. Bare metal stents have proven useful in the repair of intimal flaps; however, they are less well suited for the treatment of arteriovenous fistulas or pseudoaneurysms. Covered stents are ideally suited for repairing these lesions as well as traumatic transections [7]. Covered stent placement for the repair of traumatic arterial injury offers the advantage of decreased morbidity given that a remote access site may be used, avoiding the extensive surgical dissection associated with these injuries [8].

The potential for stent compression, stent fracture, and in-stent stenosis is well documented, especially in arteries subject to strong mechanical forces [9]. In a previous review of endovascular management of thoracic outlet trauma by Hershberger et al., mean follow-up for patients in which a stent or stent graft was placed for subclavian or axillary artery injury was 18 months and 13 months, respectively. During the follow-up period, eight patients (8.8 %) had documented stent fracture, stenosis, or occlusion and three of the eight patients with stent complications were asymptomatic. Eleven complications occurred in the subclavian artery injury group (13.8 %) [5]. These included pseudoaneurysms at the access site [9], arm claudication occurring 3 months after stent placement [10], stent fracture requiring placement of a second stent [11, 12], stent graft thrombosis, and diminished distal pulses occurring 4 months after initial treatment requiring balloon angioplasty [13]. Three deaths were documented in the subclavian artery injury group [15]. The peri-procedural death rate was 3.8 % [5], with one death occurring less than 30 days after the injury as a result of multisystem organ failure. Two deaths occurred at greater than 30 days after the injury [14].

Despite the abovementioned limitations, stent grafting within the subclavian arteries provides short-term advantages. In the hemodynamically unstable patient, stent grafting eliminates the need for thoracotomy, sternotomy, and clavicular resection. Furthermore, endovascular repair does not preclude future open repair and can, thus, be used as a bridge to definitive therapy in the hemodynamically unstable patient. In regards to stent fractures, these can often be revised via endovascular techniques.

Recommendations for follow-up are variable throughout the literature. In our practice we recommend a CTA and duplex at 1 month postoperatively then a duplex at 3 months, 6 months, 12 months, 18 months, 24 months, and then yearly thereafter. Unfortunately, the follow-up of trauma patients as a whole is often poor due to patient noncompliance. This should be considered prior to performing aggressive endovascular management.

Case Study

A 22-year-old male sustained a zone 1 stab wound of the right neck. He had immediate weakness and paresthesias in right arm. He was initially evaluated at an outside hospital where a chest tube was placed for a right pneumothorax which put out 500 ml of serosanguinous fluid. Computed tomography with intravenous contrast noted a concern for an intimal flap of the right subclavian artery.

On physical exam the patient was noted to have a 3 cm stab wound at the root of the neck, 1 cm lateral to lateral SCM border. His right upper extremity exam noted a palpable radial pulse. His motor exam had the following deficiencies due to a likely brachial plexus injury: 4/5 deltoids, 0/5 biceps/triceps, 0/5 forearm flexors/extensors, 0/5 intrinsic hand muscles, and 2/5 pronation and supination. The patient did not have sensation to fine touch or pain below the mid-humerus.

He was taken to the angiography suite. An arch aortogram was performed followed by selective catheterization of the right subclavian artery. A partial transection of the right subclavian artery was noted (Figs. 11.1a, b, 11.2, and 11.3), for which an atrium 7×22 covered stent was placed. Post-deployment revealed a mild filling defect and improper apposition of the stent to the artery wall; therefore, it was postdilated with a 9×2 balloon which revealed good apposition. No residual filling defects or contrast extravasation were appreciated (Fig. 11.4). Postoperatively it was noted that the subclavian artery as well as the internal mammary and vertebral artery were patent.

How to Do It: Femoral Access

1. Whenever intervention with stent implantation is anticipated, we typically give prophylactic antibiotics with Ancef.
2. Needle access to the right common femoral artery is obtained starting with a micropuncture set and then exchanging out for a 10 cm 5 Fr sheath.
3. 80 units/kg of IV heparin is given and a pigtail catheter is placed to the level of the ascending aorta. Arch aortogram is performed. We routinely initiate systemic anticoagulation prior to any aortic arch manipulation.
4. Selective catheterization of the brachiocephalic artery is performed with a Simmons 2 catheter and wire access across the lesion is obtained. Other options for catheterization of the brachiocephalic include a Simmons 1 or headhunter.
5. Over an Amplatz or similar stiff wire, a 90 cm 7-French sheath is placed at the level of the subclavian orifice.
6. Angiogram is performed through the sheath to confirm the location of the injury.

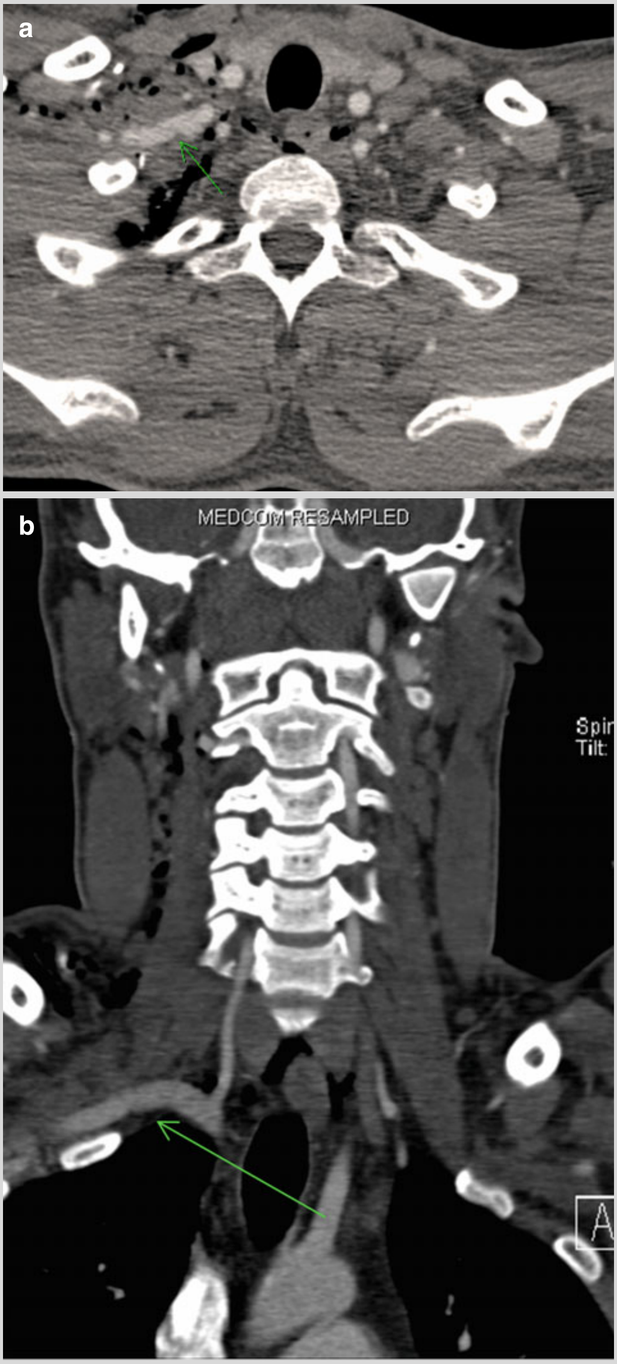

Fig. 11.1 (**a**, **b**) Axial and coronal computed tomography of patient's injury. *Green arrows* partially transected subclavian artery

7. Wire acce ss across the lesion is performed with a hydrophilic wire and guiding catheter. Angiogram is performed distal to the lesion to confirm that the catheter is intraluminal. The sheath, with dilator in place, is subsequently advanced through the lesion.

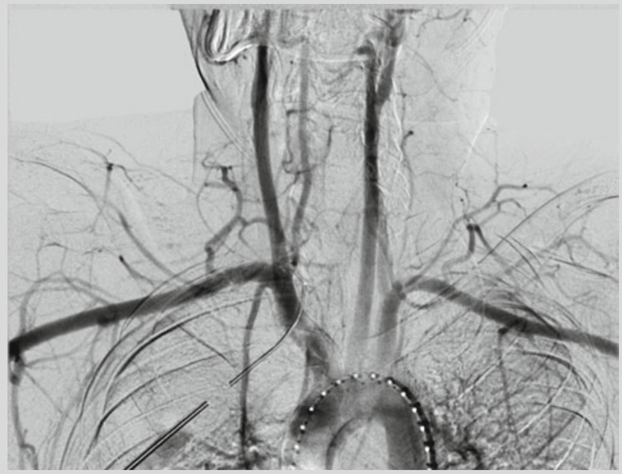

Fig. 11.2 Diagnostic aortogram showing right subclavian artery injury

Fig. 11.3 Diagnostic angiogram revealing right subclavian artery transaction

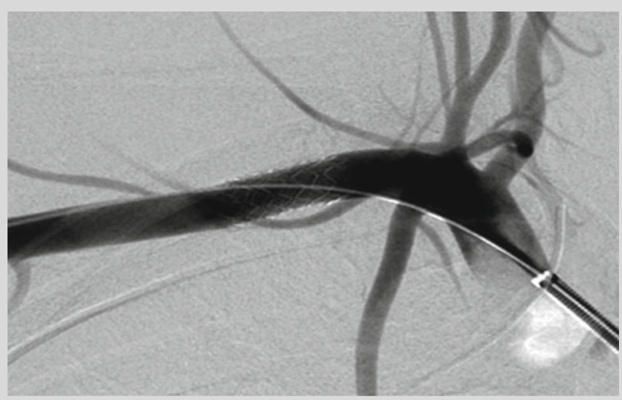

Fig. 11.4 Completion angiogram following deployment and post-dilatation of iCAST stent

8. The covered stent is placed across the lesion, within the sheath. Significant oversizing should be avoided

and at least 1 cm of seal both proximally and distally should be obtained.

9. The sheath is withdrawn over the endoprosthesis while maintaining wire access. The covered stent is subsequently deployed.
10. Angiogram is performed to confirm appropriate apposition of the stent to the artery wall. iCAST (Atrium, Hudson New Hampshire) stents have the option of being balloon dilated to a larger diameter.
11. The wire is removed from the aortic arch under direct visualization.
12. If maintenance of sheath access is needed, the 90 cm sheath can be exchanged for a short sheath.
13. If the sheath can be removed, method of access closure is left to the discretion of the operator. Our preference is manual pressure in situations where systemic anticoagulation does not need to be continued.

How to Do It: Brachial Access

1. Whenever intervention with stent implantation is anticipated, we typically give prophylactic antibiotics with Ancef.
2. Ipsilateral brachial artery access with a retrograde approach is performed. Our preference is to use a micropuncture kit whenever we gain brachial access. If it is felt that the brachial artery is not large enough to accommodate a 6–8 Fr sheath, our preference is to perform a brachial artery cutdown under local anesthetic.
3. Diagnostic arteriogram is performed to visualize the lesion. This can be performed using a glide catheter placed just proximal to the suspected injury. Great care needs to be taken that the injury is not crossed prior to angiography to ensure the location and degree of injury is evaluated. This will ensure that wire manipulation across the lesion does not inadvertently worsen the injury.
4. The lesion is crossed, typically with a combination of hydrophilic wires and guiding catheters. It is ideal to have adequate length of wire access across the lesion, typically into the descending thoracic aorta. It is imperative to ensure that true lumen is maintained with an angiogram proximal to lesion.
5. If needed, the wire is exchanged for an Amplatz 0.35 wire (or wire of similar stiffness) in order to provide rail for placement of stent and balloons.
6. The 5 Fr sheath is exchanged for 6–8 Fr 45 cm destination sheath, placing the sheath completely across the lesion.
7. The covered stent is placed across the lesion, within the sheath, avoiding significant oversizing. In addition, at least 1 cm of seal both proximally and distally should be obtained.
8. The sheath is withdrawn proximal to the endoprosthesis while maintaining wire access in the thoracic aorta.
9. The endoprosthesis is deployed and, if needed, post-dilated with a balloon with a diameter 1–2 mm larger than the stent's diameter.
10. Completion angiogram is performed to ensure adequate treatment of the lesion and appropriate stent apposition to the arterial wall.
11. Distal pulses are interrogated, and, if felt to be adequate, the sheath and wire are removed.
12. Pressure is held at the access site; it is not our practice to use closure devices in brachial artery access.

An algorithm for the management of subclavian artery trauma is found in Fig. 11.5.

Relative Contraindications for Endovascular Repair [15]

- Substantial venous injury (i.e., transection)
- Refractory hypotension
- Upper extremity compartment syndrome with neurovascular compression
- Coverage of the vertebral artery during repair

Contraindications to Endovascular Repair [15]

- Long segmental injuries
- Injuries without sufficient proximal or distal vascular fixation points
- Subtotal/total arterial transaction

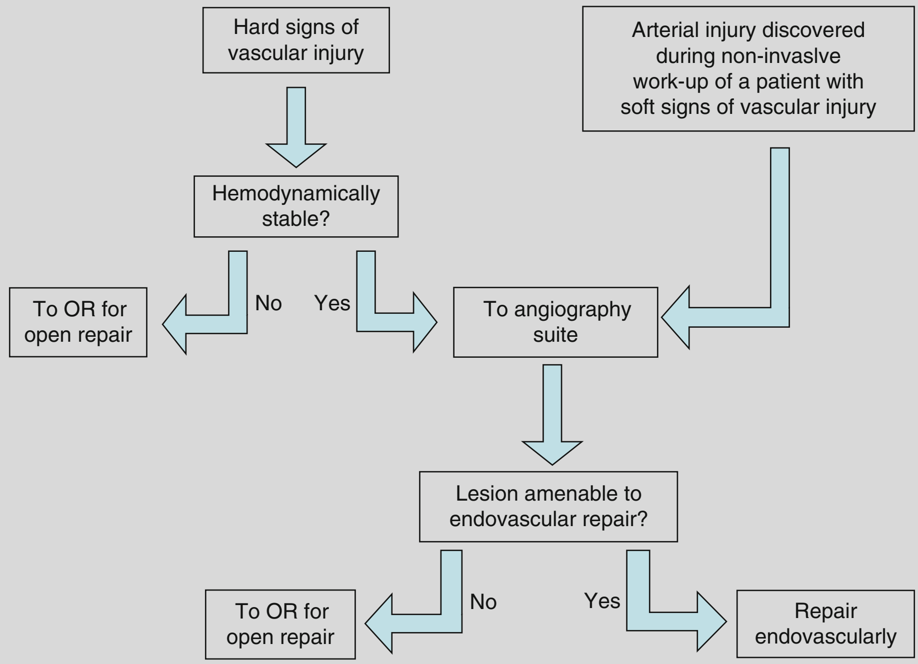

Fig. 11.5 Algorithm for management of subclavian artery trauma

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