Endovascular Management of Iatrogenic Subclavian Artery Catheterization During Single-Incision Chest Port Placement

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ABSTRACT: The chest port is an integral part of the treatment of various malignancies. Placement of this intravascular device is achieved most commonly through a double-incision approach and recently by utilizing a newer single-incision technique. The single-incision technique is associated with better cosmetic outcomes, decreased infection rates, and less tissue injury. In this case, during routine double port placement utilizing single-incision subcutaneous infraclavicular approach, inadvertent catheterization of the right subclavian artery at the origin of the right vertebral artery was noted. The defect was repaired with a novel approach utilizing a 7 mm x 7 mm HyperForm compliant balloon (Covidien) under fluoroscopic guidance. At the conclusion of the procedure, the patient had no neurologic deficits and intact vascular exam of the upper extremities.

Implantable vascular access devices are critical for intravenous delivery of chemotherapeutic agents in patients undergoing cancer treatment. The traditional double incision technique for port placement involves a small incision in the neck for internal jugular vein (IJV) access, and then advancement of the catheter percutaneously from a second infraclavicular incision in the chest. Alternatively, IJV access can be established through the pocket created by single excision and infraclavicular advancement of a customized micropuncture needle. However, this procedure requires a refined set of interventional skills and may be associated with a learning curve for less experienced operators. Complications of the single-incision approach may be similar to the traditional double-incision method, including pneumothorax, hemorrhage, infection, thrombosis, and arterial injury. Arterial injury by itself can result in extensive bleeding, arterial dissection, thrombosis, and formation of a pseudoaneurysm. At the time of this case report no intraprocedural complications of this approach have been reported in the literature. This is the first reported incident of inadvertent subclavian artery catheterization during an attempted single-incision port placement, successfully managed using a HyperForm occlusion balloon system (Covidien) to achieve hemostasis at the site of the arteriotomy.
A 58-year-old male with a history of pancreatic cancer presented for a double-lumen port placement. This was the first single-incision approach performed by an interventional radiology primary operator under supervision of an attending physician. After a single chest incision, what appeared to be a right internal jugular vein was entered under ultrasound (US) from a subcutaneous infraclavicular approach, using a custom shaped needle, the 21-gauge 7-cm echogenic super sharp needle standard Micro-Introducer Kit (Angiodynamics). Once the 0.018˝ wire, a 4 Fr Standard Micro-Introducer Kit (Angiodynamics) was placed into what was considered correct location, a 0.035˝ angled glide stiff Radiofocus guidewire (Terumo Interventional Systems) was advanced, and over the wire, an 8 Fr Brite Tip vascular sheath introducer (Cordis Corporation) was advanced under continuous fluoroscopic guidance. After multiple unsuccessful attempts to pass the wire down the inferior vena cava, contrast was injected through the sheath, demonstrating that the access was through the right subclavian artery at the origin of the right vertebral artery.

Next, access through the right femoral artery was performed, and a 6 Fr Envoy Guiding Catheter (DePuy Synthes) was used to selectively catheterize the brachiocephalic trunk. Subsequent aortogram demonstrated a normal aortic arch, right vertebral, and common carotid as well as a dominant left vertebral artery. Additionally, the entry site of the sheath was seen adjacent to the origin of the right vertebral artery (Figure 1).

The 8 Fr sheath was exchanged for a 6 Fr AccuStick II Introducer System (Boston Scientific) at the site of the lesion. A 7 mm x 7 mm HyperForm compliant balloon was advanced into the right subclavian artery up to the site of arteriotomy under fluoroscopic guidance. As the balloon was inflated, the 6 Fr AccuStick II sheath was retracted into the subcutaneous tunnel over the gold tip wire and left in place in case an emergent reentry into the arteriotomy was necessary. With the balloon in place and inflated, brachiocephalic angiogram demonstrated no evidence of extravasation at the site of the arteriotomy with maintained patency of the right vertebral and common carotid arteries (Figure 2). After 20 minutes, the balloon was deflated, and injection of contrast revealed no evidence of extravasation.
contrast demonstrated continued extravasation of contrast in the area of injury. The balloon was reinflated for an additional 20 minutes, and the subsequent angiogram demonstrated patent right common carotid, right vertebral, and right subclavian arteries without any areas of vasospasms or extravasation (Figure 3). The sheath and the wire were then removed; no hematoma or swelling in the supraclavicular fossa was noted. Heparin was not administered due to balloon occlusion at the subclavian artery site. At the conclusion of the procedure, the patient had no neurologic deficits and a vascular exam of the upper extremities showed intact vasculature.

**DISCUSSION**

Ultrasound-guided catheter placements by interventional radiologists have largely replaced surgical placement of chest ports because of the decreased incidence of pneumothorax, hemothorax, and arterial injury associated with surgical procedures. In addition to two incisions, one at the IJV access site and another in the chest for the port placement, the standard technique also requires tunneling of the catheter toward the IJV puncture site, which is traumatic to surrounding tissues and can cause hematoma and ooze from the tract. In patients with tracheostomy or with soft tissue damage of the cervical area (i.e. post radiation dermatitis, surgical scars), the venotomy may not be possible or can be prone to infections. Moreover, catheter placement through a peel-away sheath without a protective valve requires patients to hold their breath to prevent air embolism when undergoing placement via double incision method. In expert hands, the single incision approach is an elegant option that addresses the above-mentioned limitations. It is associated with less risks and
better cosmesis. There are no reported occurrences of air embolism in the reviewed literature to date, likely related to the hemostatic diaphragm that the sheaths are equipped with. Patients with coagulopathy, have significantly reduced risks of post-operative bleeding because the venotomy at IJV is avoided.³ Advance-ment and positioning of the micropuncture needle for IJV placement under US guidance requires a learning curve from the operator and may be the limiting factor in adoption of this technique.

Procedural complications involving the subclavian artery during central venous catheter placement have previously been reported.¹¹ Specifically, arterial punctures with small needles occur in 5% of cases but are mostly benign,¹² and while the incidence of arterial injury with an introducer sheath is lower at 0.1% to 0.8%, the consequences are much more serious and include hematoma, arterial dissection, hemothorax, arteriovenous fistula, pseudoaneurysm, emboli and stroke.⁶,¹³ Catheter diameter, catheter indwelling time and puncture sites directly correlate with possible complications. A variety of techniques exist for repair of iatrogenic subclavian arteriotomies including manual compression, suture-based approaches, collagen plug utilization, and endoluminal stenting.

In our reported complication, the inadvertent arterial puncture may have been the consequence of a through-and-through transvenous arterial trajectory of the curved needle. Anatomically, the subclavian artery may course immediately posterior to the internal jugular vein, especially in older patients with elongated and supraclavicular coursing arteries. Operators adopting this technique need to perform a rigorous preprocedural ultrasound identification of the neck vasculature. In addition, care has to be taken to avoid inadvertent displacement of the needle during exchange maneuvers.

Because the smaller peel-away sheath provided with the kit is not suitable for placement of the port catheter, an 8 Fr vascular sheath is instead employed at our institution. After attempting venous access, the operator placed the 8 Fr sheath. The sheath was subse-sequently used to confirm the suspected intra-arterial position. In this case, manual compression to achieve hemostasis was avoided because it carries up to a 27% complication rate as reported by Guibert et al, with the worst outcome of thrombosis of right internal carotid artery and subsequent stroke and death.¹¹ At our institution the Angio–Seal device (DSM) is utilized for vascular closures. Because it requires a straight angle for successful deployment, the mechanical constrains of the subcutaneous infraclavicular approach in this case would have led to unpredictable results. An endoluminal stent graft to repair the subclavian artery defect was another modality to consider. However, there was a concern about graft compression, stenosis, or fracture.¹⁴ While a dominant left vertebral artery was identified, the risk of occlusion or thrombosis of the right vertebral artery remained significant with either AngioSeal or endoluminal stent.

Temporary balloon tamponade is an attractive alternative technique, which offers an improved safety profile in the management of subclavian artery injury compared to other methods.¹⁵ Only individual case reports and small series of patients treated with temporary balloon tamponade have been published between 1991 and 2011. Technical success was achieved in all of the previous studies and no procedural or long-term
Complications have been reported. The decision to use a 7 mm x 7 mm HyperForm balloon was based on its advantageous characteristics including its compliance to precisely conform to the subclavian arteriotomy and its low profile shaft. The 2.8 Fr HyperForm balloon catheter was placed through a 6 Fr Envoy sheath. While the immediate advantage of a smaller arteriotomy size at the femoral artery is clear, it also allowed us to perform angiographies without the need to deflate and remove the balloon. Thus, satisfactory balloon occlusion was verified with precision at the site of the injury. This is contrary to the technique described by Yu et al., where the balloon position could not be immediately evaluated through the sheath angiogram and necessitated balloon deflation and removal as part of the procedural algorithm. This inconvenience is completely eliminated with the current approach.

An average of 300 chest ports are successfully placed at this institution each year and this is the first procedural complication during a single-incision technique chest port placement. It was the first single-incision case performed by the primary operator early in his training, underscoring the learning curve associated with this approach. Two weeks after the incident, the patient returned for a successful port placement via a double-incision technique, which was performed uneventfully.

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