Case Report

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A Novel Approach to the Management of Inadvertent Subclavian Artery Cannulation Using Angio-Seal Closure Device: A Case Series

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Abstract

Background: Inadvertent arterial cannulation is a well-known complication of subclavian central venous catheterization. While this complication at other sites can be managed through prompt identification of catheter misplacement, followed by catheter removal and application of manual compression, subclavian artery cannulation offers a unique challenge to effective management due to its incompressible anatomic location. Current treatment options for inadvertent subclavian artery cannulation include direct surgical repair or endovascular treatment with stent graft placement. We report 3 cases of patients with inadvertent subclavian artery cannulation which was safely and effectively managed utilizing a novel technique using the 8Fr Angio-Seal vascular closure device.

Methods: Three patients with inadvertent puncture of the subclavian artery during Central Venous Catheter (CVC) placement were treated with 8Fr Angio-Seal deployment. Patient 1 is a 53-year-old found hemodynamically unstable and unresponsive, undergoing emergent central line placement in the emergency department. Patient 2 is a 29-year-old female who was a burn patient undergoing central line placement in conjunction with planned skin graft placement. Patient 3 is a 57-year-old female with congestive heart failure who underwent central line placement at an outside hospital and transferred to a quaternary center for inadvertent subclavian artery cannulation after central line placement attempt.

Results: Management of inadvertent subclavian artery cannulation was safely and successfully achieved utilizing the 8Fr Angio-Seal vascular closure device to create a mechanical seal in all three patients. The closure device can be deployed into the subclavian arteriotomy utilizing the original 7Fr central venous catheter. The technique is immediately effective, requires a few minutes for deployment and was performed at bedside. Subsequent imaging revealed patent and intact subclavian artery.

Conclusions: Utilization of Angio-Seal vascular closure offers a rapid, inexpensive, and efficient way to repair inadvertent subclavian artery cannulations by triple lumen catheters at bedside in the ICU, ER, and OR. This percutaneous approach offers a shorter recovery time and avoids operative complications of open surgical repair.

Keywords: Subclavian artery cannulation; Central venous catheter

Introduction

Insertion of a CVC is a routinely used technique in the emergency room, operating room and intensive care unit settings to establish a reliable venous pathway for fluid resuscitation, intraoperative volume support, and medication administration. This technique utilizes a Triple-Lumen Catheter (TLC) and common anatomic approaches used to establish venous access include the internal jugular, subclavian and femoral approaches. Central venous catheterization is associated with an array of potential adverse events that can be divided into immediate and delayed complications. Immediate complications arise directly after CVC insertion and include mechanical complications, while delayed complications consist of infectious and thrombotic events [1].

Inadvertent arterial puncture is one of the common mechanical complications of central venous catheterization, alongside hematoma and pneumothorax [2]. Arterial puncture can occur as a result of blind and, less commonly, ultrasound-guided catheterization, often during tenuous emergency situations [3]. Arterial injury not only exacerbates patient discomfort in the context of pre-existing critical illness but is also associated with significant morbidity and mortality and can lead to other iatrogenic complications, including subclavian artery pseudoaneurysm [4]. Furthermore, in subclavian artery puncture, the incompressible anatomical position of the affected vessel may not allow for effective tamponade with application of direct compression to achieve hemostasis, putting patients at risk for fatal exsanguination [1,5]. Therefore, in the short-term and in the absence of a standard of care for arterial injury management, the misplaced device is often left *in-situ*, and vascular interventional consultation is obtained for management recommendations [6].

Injury management ranges from endovascular covered stent placement and more invasive open surgical repair. While the

safety of open surgical treatment has been demonstrated, it is associated with additional, significant morbidity, as the open repair is technically complex, and patients are often critically ill [7]. Endovascular treatment can be safe, but do require additional access site for placement of covered stent [8]. We have used Angio-Seal® (St. Jude Medical, St. Paul, MN, USA) as a direct percutaneous treatment of inadvertent arterial injury. This device creates a mechanical seal, which sandwiches the arteriotomy between a bio absorbable anchor and a collagen plug.

The aim of this report is to describe 3 cases of successful bedside percutaneous closure of subclavian artery punctures secondary to CVC insertion in a variety of clinical settings utilizing the Angio-Seal device. This minimally invasive technique is a promising way to repair inadvertent arteriotomy during central venous catheterization. We demonstrate a safe, cost-effective percutaneous approach that allows prompt and safe removal of a TLC placed in the subclavian artery.

Case Presentations

Case one

This is a 53-year-old female with past medical history of ventilator dependent amyotrophic lateral sclerosis was brought in by EMS due to unresponsiveness due to diabetic ketoacidosis and pneumonia. Decision for central line placement was made in the emergency room due to hemodynamic instability. A 7Fr TLC was introduced in the left infra-clavicular region for left subclavian vein access. A blood gas was obtained from the TLC which revealed arterial placement. Vascular surgery was immediately consulted, and we advised to leave the central line in place. At this time decision was made for placement of Angio-Seal closure device.

Under sterile technique a J-wire was then placed into the TLC. The TLC was then removed. The dilator was then placed back over the wire. The Angio-Seal device wire was then placed into the subclavian artery. An 8Fr Angio-Seal delivery device was then placed into the left subclavian artery.

The patient was noted to have good back bleeding through the device. The inner cannula was then removed. The plug was then placed through the device up to the subclavian artery and deployed at the site. After the deployment, the patient was noted to have no further bleeding from the subclavian artery. The patient underwent evaluation of the left upper extremity and was noted to have good Doppler signals at the left radial artery.

A post-procedure chest X-ray showed no pneumothorax following line removal. Two days after the procedure, a sonogram of the arterial and venous system of the left upper extremity demonstrated that the subclavian, axillary and brachial arteries and veins were patent with expected waveforms and no evidence of clinically significant stenosis or pseudoaneurysm. Patient had follow-up of 5 months with no procedure related complication.

Case two

This is a 29-year-old female with a 10% total body surface area burn after falling from a chair and landing on a radiator. She underwent left subclavian TLC placement in the operating room prior to a skin graft procedure. Patient was noted to have pulsatile flow from the TLC and inadvertent subclavian arterial placement was confirmed by X-ray and Arterial Blood Gas (ABG).

At this time, vascular surgery was consulted for removal of the left subclavian artery catheter with repair of the artery. A decision was made to use an Angio-Seal device for the repair of the artery. A guide wire access was obtained from the TLC. An 8Fr Angio-Seal device was then deployed into the left subclavian artery. The patient was noted to have no significant bleeding after the procedure. The patient was noted to have intact left brachial artery pressure after the procedure. The patient tolerated the procedure well and went on to have skin graft surgery.

A post-procedure chest X-ray showed no pneumothorax following line removal. A duplex ultrasound of the left subclavian and axillary arteries was performed which showed patent left subclavian and axillary arteries without evidence of hematoma or pseudoaneurysm. Patient had follow-up of 14 months with no procedure related complication.

Case three

This is a 57-year-old female with a past medical history of Chronic Obstructive Pulmonary Disease (COPD), hypertension and congestive heart failure, who was admitted to a community hospital for sudden-onset dyspnea. She was treated for hypertensive urgency and pulmonary edema, with central line placement during her hospital course. She was transferred to our institution for TLC removal due to arterial puncture at the junction of the left subclavian and left vertebral arteries.

The patient was brought to the cardiac catheterization lab for removal of the left subclavian catheter with placement of Angio-Seal device. First an angiogram of the left subclavian artery was performed by accessing the right common femoral artery. The selective left subclavian artery angiogram revealed that the entry point of the TLC was approximately 1 cm away from the left vertebral artery.

The TLC was removed and the Angio-Seal device was deployed. Repeat angiogram from the femoral access site showed a patent left subclavian artery without evidence of extravasation. Patient had follow-up of 13 months with no procedure related complication in **Figure 1.**

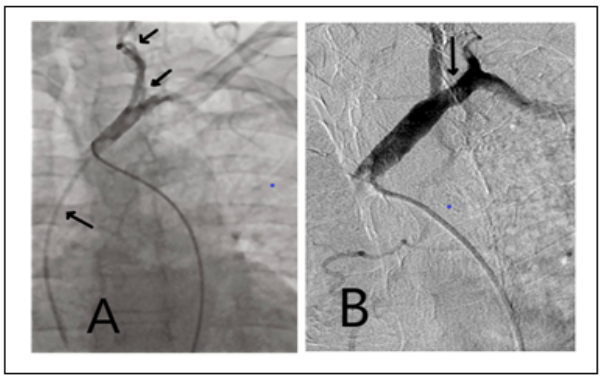

Figure 1: (A) Angiogram with arrows showing inadvertent catheter entering the left subclavian artery distal to the vertebral artery. (B) Angiogram of the left subclavian artery after removal of the catheter with arrow showing site of Angio-Seal placement.

Discussion

Our report describes successful percutaneous treatment of inadvertent subclavian artery puncture utilizing the Angio-Seal device in three patients who underwent central venous catheterization in different clinical settings. The management of inadvertent arterial catheters depends on the location of the catheter, duration the catheter is left in the artery and the clinical condition of the patient. Effective management is paramount to improving outcomes in the critically ill patients who have arterial injury secondary to CVC placement [9].

Arterial closure devices such as Angio-Seal were developed to obtain hemostasis after arterial catheterization procedures [10]. Compared to manual compression, the use of arterial closure devices has been shown to improve patient comfort, reduce time to ambulation, and shorten hospital length of stay. Kirkwood, et al. [11] reports similar achievement of appropriate hemostasis in an ICU patient with a history of severe congestive heart failure who had inadvertent right subclavian artery puncture during attempted CVC placement [12].

Open surgical intervention is one option for closure of inadvertent subclavian arterial injury. Surgical repair may require a supraclavicular incision, partial removal of the first rib, and/or a thoracotomy, the more invasive nature of which is associated with high morbidity and mortality in critically ill patients. In addition, possible complications of open surgical repair are similar to that of penetrating subclavian artery injury, which include injury to the brachial plexus and subclavian vein [9].

Endovascular treatment is another treatment option for subclavian artery injury with placement of covered stent graft into the artery while removing the catheter under fluoroscopy. This involves brachial, radial, or femoral access for stent graft delivery. This procedure necessitates angiography suite capabilities [8].

A case series by Szkup, [12] also demonstrates safe, efficacious percutaneous closure of subclavian artery injury due to inadvertent catheterization in a patient transported to an angio-suite [13]. Other vascular closure devices such as the star close have also been shown to be effective at achieving successful arteriotomy closure [14]. Markis, did a systematic review of closure devices showing that they are effective in treating inadvertent arterial injuries; however long term data was limited [14].

Conclusion

In conclusion, our study demonstrates that the Angio-Seal device is an effective and efficient way to repair inadvertent arteriotomies caused by triple lumen catheters. This bedside procedure allowed for prompt, uncomplicated removal of a triple lumen catheter in the ICU, OR, and ER without requiring patient transport. This technique avoids operative complications and angiography suite requirements. While promising, further research is needed to elucidate the long-term risk benefits of percutaneous Angio-Seal closure of inadvertent arterial catheter in a larger series of patients.

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