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A rare case of a blunt thoracic aortic injury in a patient with an aberrant right subclavian artery: A case report and literature review

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ABSTRACT

INTRODUCTION: Blunt thoracic aortic injuries (BTAIs) are an uncommon traumatic injury that if not treated promptly, can result in death. We present the case of a BTAI with aberrant aortic anatomy.
PRESENTATION OF CASE: A 60-year-old female was involved in a motor vehicle crash where she suffered significant polytrauma including a BTAI. She was also found to have an aberrant right subclavian artery originating from the aortic arch. Thoracic Endovascular Aortic Repair (TEVAR) with a right common carotid artery to right subclavian artery bypass was accomplished. She required three more vascular surgical interventions, two for persistent type II endoleak and the third for left upper extremity acute limb ischemia. She had a 2-month hospital course for her devastating injuries and was eventually discharged home. A follow-up CT angiogram showed a stable thoracic aortic arch stent.
DISCUSSION: BTAIs are uncommon in the trauma population. In our patient who had an aberrant right subclavian artery, further procedures were required in the form of a right common carotid artery to right subclavian artery bypass and embolizations to resolve endoleaks.
CONCLUSION: Blunt thoracic aortic injuries are life threatening and require urgent intervention. TEVAR is associated with better outcomes. An aberrant right subclavian artery originating from the aortic arch, distal to the left subclavian artery is an anatomic variant that adds significant complexity to TEVAR. TEVAR is still an option for repair of blunt thoracic aortic injuries despite anatomic variations as open repair still carries an increased risk of morbidity and mortality.

1. Introduction

Blunt thoracic aortic injury (BTAI) is a known but uncommon finding and has been estimated to account for <1% of trauma admissions to Trauma Centers [1]. The most common mechanism for development involves some form of rapid deceleration, typically via a motor vehicle collision (MVC) or fall from a significant height [2]. The thoracic and mediastinal contents vary in their fixation within the chest wall. Therefore, relative mobility can allow for significant stress on transition points allowing for traumatic rupture. This is most commonly seen at the aortic isthmus near the ligamentum arteriosum. However, other mechanisms of action for blunt aortic injury have been proposed [3].

While a rare entity in trauma, BTAI carries significant mortality risk. As non-compressible exsanguination can rapidly develop, prehospital mortality has been shown to be significant, with only 15% estimated survival to hospital admission [4]. Of those who do survive to hospital admission, overall hospital mortality is 44%. Those who survive to operative repair have mortality rate of 17% [5]. The devastating course of BTAI speaks to the inherent necessity for timely transport, identification on intake, and rapid intervention in order to maximize probability of good patient outcomes.

Previously, the mainstay of definitive management for BTAI involved open surgical repair with thoracotomy and aortic cross clamping. Cardiopulmonary bypass has been a debatable option. Such surgical intervention did not come without risk, as postoperative mortality and complications have been documented to be high [6]. As an alternative means of intervention, Thoracic Endovascular Aortic Repair (TEVAR) has rapidly grown in popularity for managing BTAI. TEVAR offers a less invasive approach and has been associated with significantly better injury-adjusted all-cause mortality [7].

While TEVAR is an effective treatment for BTAIs, this procedure could be complicated by significant concomitant injury or anatom-

Abbreviations: BTAI, blunt thoracic aortic injury; MVC, motor vehicle collision; TEVAR, Thoracic Endovascular Aortic Repair; GCS, Glasgow Coma Scale; CT, Computed Tomography; CTA, Computed Tomography Angiography; MRI, Magnetic Resonance Imaging; PTFE, polytetrafluoroethylene; HIT, Heparin Induced Thrombocytopenia; HITT, Heparin Induced Thrombocytopenia and Thrombosis; ISS, injury severity score; NTDB-RDS, Nataional Trauma Data Bank Research Dataset.

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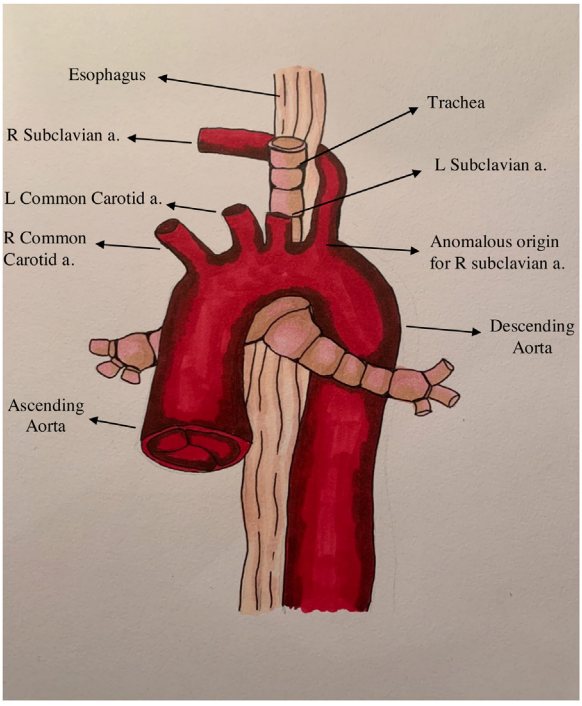

Fig. 1. Aberrant right subclavian artery anatomy.

ical variation. One such variation in anatomy is an aberrant right subclavian artery. The normal anatomy of the aortic arch includes three great vessels branching from the arch. These three vessels from proximal to distal are the innominate artery, the left common carotid artery, and the left subclavian artery. The innominate artery branches divide into the right subclavian artery and the right common carotid artery. In 0.4%–2% of the population, an aberrant right subclavian artery distal to the left subclavian artery can occur, which poses a challenge for a TEVAR repair of a BTAI (Fig. 1) [8].

We present the case of a 60-year-old female patient who presented to our Trauma Center with grade 3 BTAI (pseudoaneurysm) [9] and other significant polytrauma acquired secondary to an MVC. She was treated successfully with TEVAR despite significant anatomical variation of the aortic arch. This case is reported with consideration to the SCARE criteria [10].

2. Presentation of case

The case is of a 60-year-old female who presented to our Level 1 Trauma Center after an MVC. She had a past medical history of hypertension and hyperlipidemia. Prior to arrival at our facility, she had never had surgery before. She was the unrestrained driver who suffered a side impact by another vehicle and required a prolonged difficult extrication due to vehicle damage. Initially in the field, she had a Glasgow Coma Scale (GCS) of 9, however on arrival to the trauma bay she was a GCS 3 and hypotensive. On the primary survey she was intubated due to her low GCS. Bilateral chest tubes were placed for bilateral pneumothoraces. She was also volume loaded with a liter of lactated ringers and her hypotension improved. Her vascular examination revealed, carotid pulses were 2+/4 bilaterally and femoral pulses were 1+/4 bilaterally. Her abdominal ultrasound was negative for free fluid. Once her blood pressure stabilized she was taken to Computed Tomography (CT) imaging.

She was found to have the following injuries: grade 3 BTAI distal to an aberrant right subclavian artery (Fig. 2A&B), mediastinal hematoma, 2nd cervical (C2) vertebrae level ventral spinal cord epidural hematoma, C2 bilateral anterior arch fracture, LeFort type I facial fractures, pelvic ring fracture, bilateral pulmonary contusions, left rib fractures 1–6, bilateral pneumothoraces, 3rd thoracic vertebral body superior endplate fracture, and lumbar vertebrae 1, 2, 3, and 4 vertebral body fractures. The Computed Tomography Angiography (CTA) of the chest and neck confirmed that she had an aberrant right subclavian artery as well as a hypoplastic left vertebral artery, dominant right vertebral artery and aortic origins of the bilateral carotid arteries. Vascular surgery was contacted and an emergent Magnetic Resonance Imaging (MRI) of the neck was also obtained due to the cervical injury with epidural hematoma. Despite the patient having the neck injury, emergent anticoagulation was discussed between the vascular surgery and neurosurgery teams, and clearance for anticoagulation despite the epidural hematoma was granted.

Next, the patient was then taken to the operating room by vascular surgery. The patient underwent bilateral percutaneous femoral artery access under ultrasound guidance, thoracic angiogram, thoracic endovascular aortic repair with a Medtronic Navion (Minneapolis, MN) thoracic aortic endograft, and a right common carotid artery to right subclavian artery bypass with an 8 mm ringed polytetrafluoroethylene (PTFE) via a supraclavicular and infraclavicular incisions. For the bypass, the graft to the right subclavian artery was performed in an end-to-side fashion and the graft to the right common carotid artery was performed in an end-to-side fashion.

On postoperative day 1, a repeat CTA chest revealed a type II endoleak (Fig. 3) that was most likely due to the right carotid to subclavian bypass related to retrograde perfusion in the aberrant right subclavian artery versus a less likely native retrograde perfusion via a left subclavian artery. Due to the finding of the repeat CTA chest, the patient was taken on postoperative day 2 for a plug embolization of her aberrant right subclavian artery with a 12 mm Amplatzer plug through a right brachial artery approach.

On postoperative day 4 a repeat CTA chest was obtained that revealed an approximately 50% reduction in the prior endoleak, but persistent endoleak nonetheless (Figs. 4 and 5), most likely due to retrograde left subclavian artery perfusion which then contributed to persistent antegrade right proximal aberrant subclavian artery perfusion despite the previously placed Amplatzer plug. Due to this persistent type II endoleak, she was taken back to surgery for plug embolization of the left subclavian artery with an 8 mm × 7 mm Amplatzer plug II via a left brachial artery approach.

On the morning of postoperative day 6, she was then noted to have a change in her pulse exam of the left upper extremity. A CTA of the left upper extremity demonstrated left brachial artery occlusion with distal reconstitution of her radial and ulnar arteries, she was taken to surgery for left brachial artery exploration, open embolectomy with Fogarty balloon catheters of the left brachial, radial, and ulnar arteries, and primary repair of the left brachial artery.

On the following day, the patient developed significant thrombocytopenia, concerning for heparin-induced thrombocytopenia (HIT). Her platelets dropped from 134,000 the previous day, down to 20,000 (normal range: 182,000–369,000). Heparin drip was immediately discontinued and she was placed on an argatroban drip. The results of the follow up HIT panel did reveal she had positive antibodies and so she continued on argatroban drip until she had completed all of her surgeries, at which point she was transitioned over to rivaroxaban. Ultimately, it was revealed that the left brachial artery occlusion was caused by thrombus via HIT; HIT can predispose the patient to thrombosis, and once this happens it is labeled heparin-induced thrombocytopenia and thrombosis (HITT).

Her pulmonary status was also of concern. She underwent a tracheostomy for ongoing respiratory insufficiency secondary to her pulmonary contusions and polytrauma. Her bilateral chest tube outputs and air leak improved. The right chest tube was removed

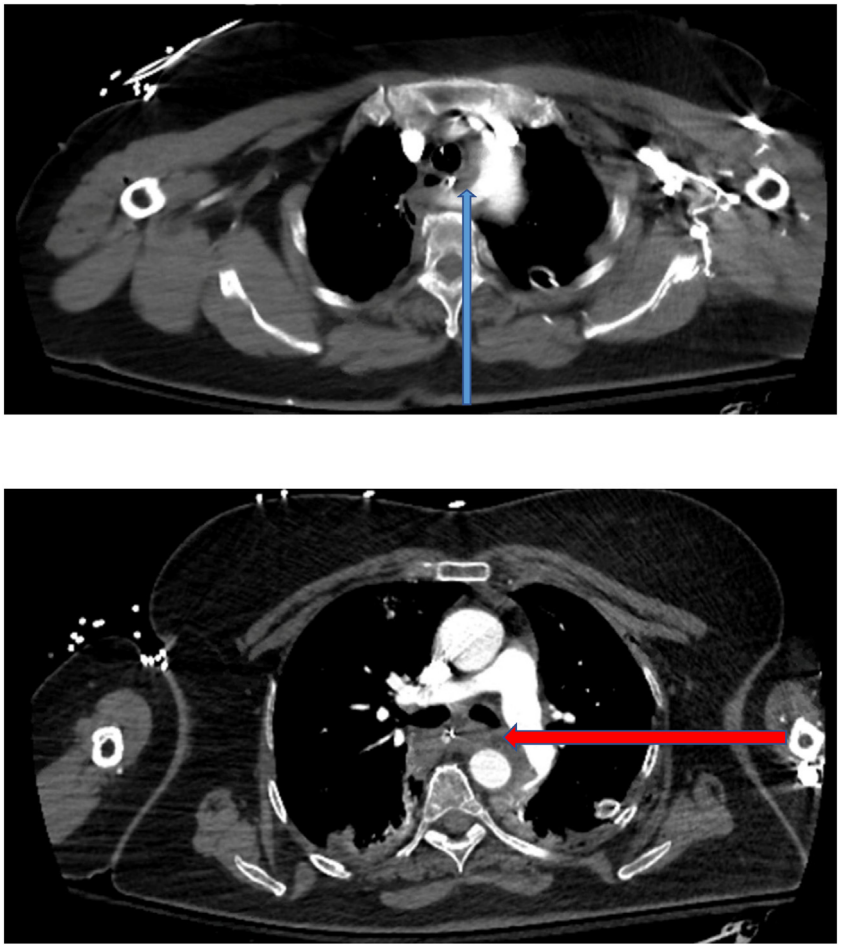

Fig. 2. A&B: CT Chest with IV contrast (different levels) demonstrating periaortic fluid (a sign of traumatic thoracic aortic rupture) as well as an aberrant right subclavian artery originating from the aorta and through the retro-esophageal region (red arrow = thoracic aortic rupture and aneurysm, blue arrow = aberrant right subclavian artery).

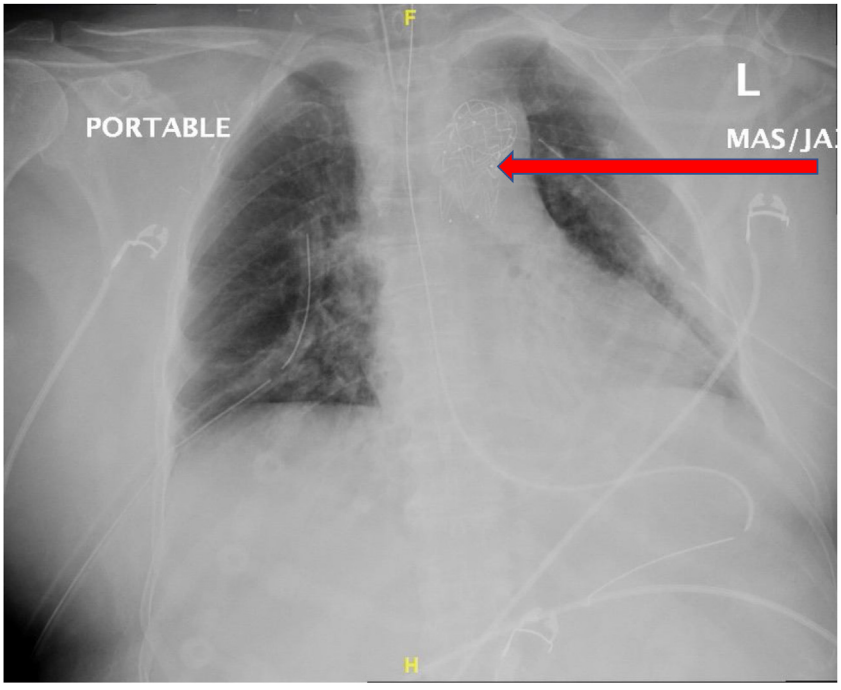

Fig. 3. Chest x-ray showing thoracic endovascular aortic repair with a Medtronic (Minneapolis, Minnesota) Navion 22 × 22 × 26 cm thoracic aortic endograft. (red arrow = thoracic endograft).

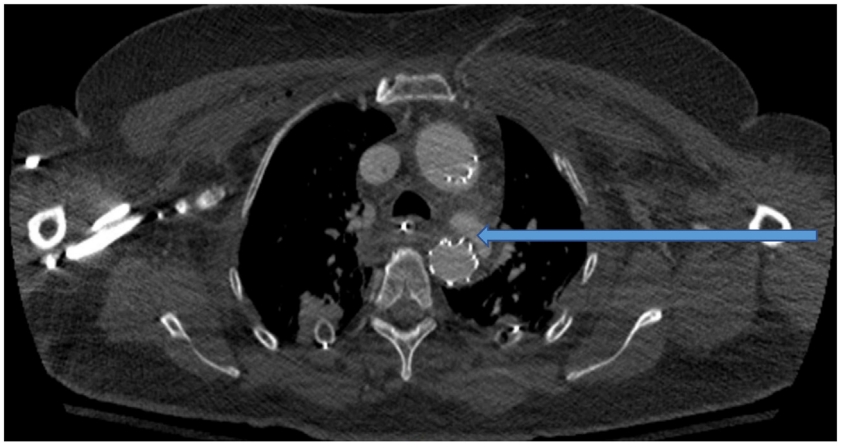

Fig. 4. CTA chest showing enhancing pseudoaneurysm with persistent contrast enhancement of the proximal descending thoracic aorta distal (grade 3 BTAI) to the takeoff of the aberrant right subclavian artery (type II endoleak) (blue arrow = endoleak).

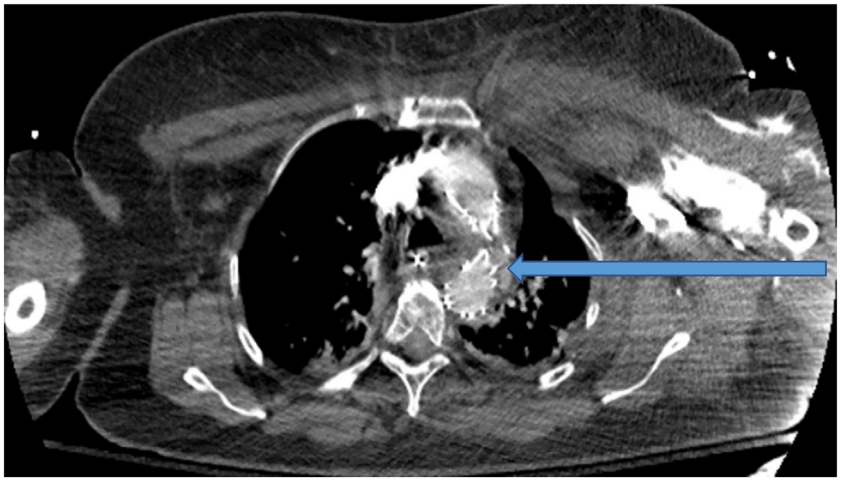

Fig. 5. CTA chest showing smaller but persistent type II endoleak (blue arrow = endoleak).

by hospital day 10 and left chest tube removed by hospital day 15. She developed a ventilator-associated pneumonia at the site of her pulmonary contusions and was treated with a 10-day course of antibiotics.

On hospital day 18, she had been doing well from her major vascular surgical procedures and so was taken to the operating room by plastics and reconstructive surgery for repair of her LeFort type I facial fractures. Regarding her pelvic ring fracture, she was treated in a non-operative fashion and required to be non-weight bearing for three months. A month after her tracheostomy had been placed, she was able to be decannulated and she eventually passed a formal swallow evaluation and was tolerating a diet. She continued to improve and was discharged home with home health after less than two months from her life-threatening polytrauma. Upon subsequent follow-up at 4 weeks and 6 weeks post discharge, she was found to have an unremarkable post-operative evaluation. On her follow-up appointment she underwent a carotid Doppler, which revealed no hemodynamically significant stenosis of bilateral internal carotids. A follow-up CT angiogram was also done. This showed stable thoracic aortic arch stent and a patent right common carotid to right axillary bypass graft.

3. Discussion

Our patient suffered significant polytrauma that was immediately life threatening. Her injury severity score (ISS) was 57 (range 1–75). Based on her ISS and her presenting vital signs, she had a probability of survival of 0.6%.

Current options for repair of BTAIs include open versus TEVAR. Before the evolution of endovascular techniques, patients had open surgical repair as their only option, which came with a high risk of morbidity and mortality [6] because the surgery typically entails a thoracotomy (and possible heart bypass). Although there are no randomized controlled trials to compare these two types of repair, vascular surgeons have generally moved towards the less invasive TEVAR for these already critically injured patients. Additionally, prior studies have shown favorable outcomes for the endovascular technique [6]. In a retrospective study analyzing the National Trauma Data Bank – Research Data Set (NTDB-RDS), TEVAR was shown to be superior to open repair for all-cause mortality (11% versus 25.2% respectively, $p < 0.005$) [7]. Endovascular repair of BTAIs has become the standard of care, when compared to open, because of the decreased morbidity, mortality, and length of hospital stay.

TEVAR is an option for BTAIs as demonstrated by Tan et al. TEVAR has been shown to be a safe treatment for BTAIs, and sacrifice of the left subclavian artery is allowed if a safe landing zone is required to place the graft and has been shown to not increase the risk of paraplegia, stroke, or left upper extremity ischemia [11,12]. Weigang et al. recommend to perform prophylactic revascularization before endovascular stent graft coverage in the stable and non-traumatic patient, however they do justify coverage before revascularize-

tion in acutely unstable patients [13]. The patient's mediastinal hematoma and hypotension deemed it necessary to address the aortic injury via endovascular approach prior to performing the bypass.

To add to the complexity of her case, her aortic arch and aortic branch anatomy was not typical. She had an aberrant right subclavian artery in which the right subclavian artery originated from the aortic arch distal to the left subclavian artery and traveled in the retro-esophageal region towards the patient's right side. While overall a rare entity, aberrant right subclavian artery is the most common abnormality of the aortic arch with a prevalence of 0.4%–2%, with 15% accounting for a retro-tracheal course and the rest of the aberrant right subclavian arteries taking the retro-esophageal course [9,14]. In addition, after her index operation, she required two further procedures to manage a type II endoleak. While the endoleak was not an unexpected finding, step-wise plug embolization was performed of her aberrant right subclavian artery on postoperative day 1, followed by plug embolization of the left subclavian artery on postoperative day 4. Current literature is lacking on the incidence of type II endoleak after TEVAR, however a tortuous aorta has been a predictive factor [15]. Additionally, in our patient her aberrant right subclavian artery anatomy contributed to her expected endoleak. Further studies should be conducted to analyze other factors predisposing to all types of endoleaks in patients who undergo TEVAR.

A case report by Patel et al. details a traumatic BTAI in a patient with aberrant right subclavian artery. This patient underwent TEVAR like our patient; however, they maintained perfusion of the left subclavian artery through a left vertebral artery [16]. In contrast, our patient had a hypoplastic left vertebral artery and a dominant right vertebral artery. Thus, the blood supply to her brain was maintained via the right common carotid artery for the anterior circulation followed by the right common carotid artery to right subclavian artery bypass, through the right vertebral artery for the posterior circulation.

While an open repair was also a viable option, we chose to proceed with TEVAR. The overall mortality of an open surgical repair of a BTAI has been shown to be around 33% despite advances in resuscitation and emergency operative techniques due to not only the nature of the injury itself, but also the other severe injuries that are concurrently sustained [17]. Due to the significant traumas the patient suffered, the least morbid procedure and the least amount of time in the operating room was of high importance. The current literature supports TEVAR being an alternative to open repair with lower postoperative mortality and ischemia to the spinal cord [18]. In our patient with other traumatic injuries that needed to be eventually addressed, endovascular intervention would have provided lower postoperative mortality.

Other potential complications that our patient could have suffered were spinal cord ischemia, stroke, and graft infection. The incidence of postoperative paraplegia from spinal cord ischemia and stroke after TEVAR for BTAI has been reportedly 1.4% and 1% respectively [19]. Although she had a cervical epidural hematoma, she required anticoagulation during her vascular operations and postoperatively, which the risks of expansion of the hematoma and compression on the spinal cord causing devastating neurologic consequences were discussed at length with the family. Additionally, providing aortic coverage before bypass put her at greater risk for suffering a stroke, however careful consideration of the risks and benefits were weighed, and patient did not suffer either complication. Graft infection has been shown to be lower in endovascular repair compared to open repair, however when this occurs, open surgical repair is required with high morbidity [20]. In our patient, careful daily monitoring for any signs or symptoms of infection allowed us to cautiously prepare for this high morbidity sequelae. Fortunately, she did not suffer any of the above complications and was able to be discharged home.

4. Conclusion

Blunt thoracic aortic injuries are life threatening and require immediate intervention. An aberrant right subclavian artery originating from the aortic arch distal to the left subclavian artery is an anatomic variant that adds significant complexity to TEVAR. TEVAR is still an option for repair of blunt thoracic aortic injuries despite anatomic variations as open repair still carries a significant risk of morbidity and mortality.

Declaration of Competing Interest

None.

Funding

None.

Ethical approval

This is a case report study. Informed patient written consent has been obtained and all identifying information was omitted.

Consent

Informed patient written consent has been obtained and all identifying information is omitted.

Author contribution

DB, MM, BD, EM, AE, KK – Conception of study, acquisition of data, analysis and interpretation of data.

DB, MM, BD, EM, AE, KK – Drafting the article.

DB – Management of case.

MM, DB, AE, BD, EM, KK – Critical revision of article and final approval of the version to be submitted.

Registration of research studies

Not Applicable.

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