



# CASE REPORT

## Blunt Partial Transection of the Innominate Artery: Anomalous Origin of the Left Carotid Artery and Off-Pump Repair

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### Introduction

Innominate artery injury occurs, although rare. The innominate artery is the second most common aortic vessel injured as a result of blunt trauma.<sup>1</sup> A blunt mechanism has been associated with up to 35% of innominate artery injuries. Associated innominate artery injuries include aortic or aortic branch injury, pneumothorax, rib fracture, head trauma, and long bone extremity fracture.<sup>2</sup>

Traditionally, surgical correction has been the preferred management option. Surgical options include the use of a graft verses primary repair, a bypass exclusion technique, cardiopulmonary bypass, and profound hypothermia or shunts, especially to maintain or protect cerebral perfusion.<sup>2</sup> Stenting is another treatment option.<sup>3</sup> The use and timing of these interventions depends on the characteristics of the innominate artery injury, associated concomitant injuries, resources of the facility, and comfort level of the surgeon.

The branching pattern of the human aortic arch is varied. These variations should be kept in mind when dealing with great vessel injuries. The term “bovine arch” will not be used to describe the aortic arch branching pattern anomaly found in the current case as a true bovine arch involves a large brachiocephalic trunk that gives rise to both subclavian arteries and a bicarotid trunk.

Two forms of human anomalous arch anatomy have been described as a bovine arch. The first arch variant is characterized as having a common origin of the innominate artery and the left common carotid artery. In a report by Layton and colleagues,<sup>4</sup> they indicated that this variant occurred in approximately 13% of patients. He also reported that the second variant, in which the origin of the left common carotid artery arises from the innominate artery, occurs in less than 10% of the general population. The presence of these anomalies may contribute to the location of a great vessel injury as well as influence the management of the resulting injury in regards to maintaining cerebral perfusion. We report the case of an innominate artery injury in a man with anomalous arch circulation and our management of the injury.

### Case Report

A 44-year-old man was transferred from an outside hospital to our American College of Surgeons verified Level 1 Trauma Center, intubated, and hemodynamically stable, after suffering crush injury due to cement and sand from a concrete mixer. Prior to intubation, field examination revealed normal mental status with complaints of back pain. Initial blood pressure and heart

rate in the trauma bay were 178/130 mmHg and 102 bpm, respectively. Following administration of pain medication, the patient's blood pressure and heart rate stabilized to 121/83 mmHg and 83 bpm, respectively. Initial chest radiograph (Figure 1) showed evidence of a widened mediastinum, loss of aorto-pulmonary window and aortic knob, and right-sided pneumothorax, prompting chest tube placement for drainage.



Figure 1. Plain chest radiograph demonstrating a widened mediastinum.

The secondary survey was positive for facial lacerations, open nasal fractures, petechiae on the upper chest, and crepitus on the mid thoracic spine. Upper extremity examination showed equal pulses bilaterally. Computed tomographic (CT) examination of the chest revealed mediastinal fullness and a questionable filling defect of the innominate artery distal to an anomalous origin of the left carotid artery (Figures 2 and 3). The CT scan also demonstrated a T6 compression fracture with no retropulsion (10-15% loss of height) and transverse process fractures (T4-8).

Given the T6 compression injury, it remained unclear whether a thoracic vessel injury or congenital web with venous oozing from the T6 compression fracture caused the mediastinal hematoma seen on CT. Angiography was performed for clarification and the radiology report indicated a finding of a focal dissection with associated pseudo-aneurysm involving the innominate artery. Distance between the origin of the aberrant left common carotid artery and the proximal portion of the disruption was 1 cm. There were 2 cm between the distal portion of the disruption and the bifurcation of the innominate artery (Figure 4).

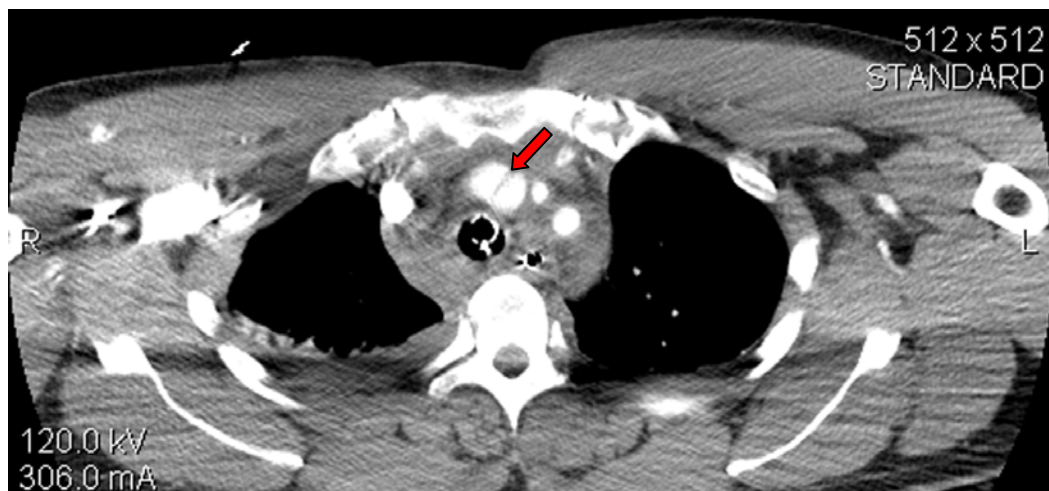


Figure 2. Chest CT scan with contrast demonstrating mediastinal hematoma as well as findings concerning for a dissection or congenital web in the innominate artery (arrow).

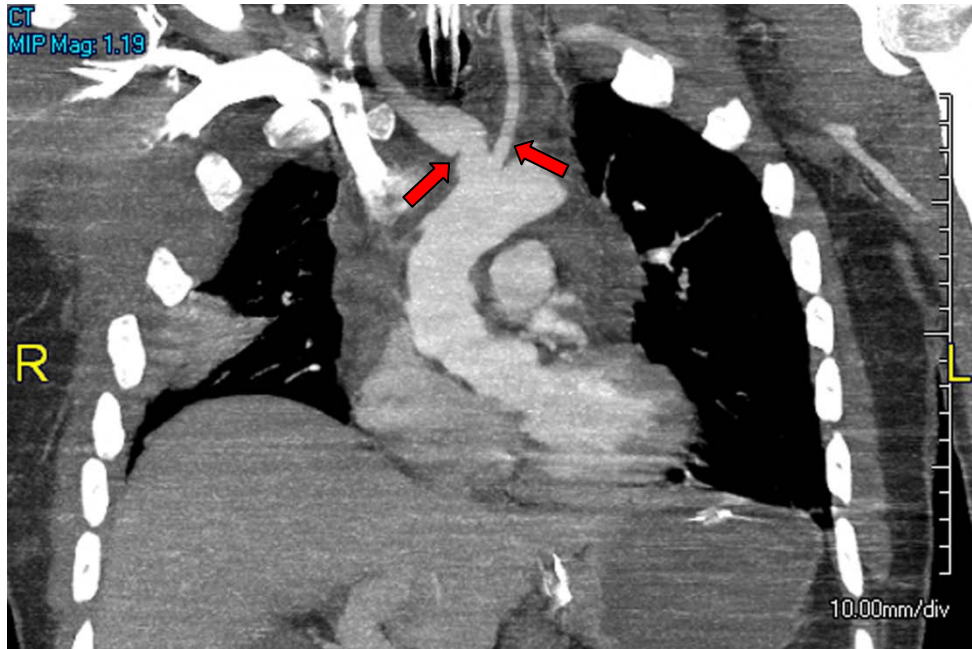


Figure 3. Chest CT scan reconstructions showing an area more suspicious for a focal dissection with an associated pseudoaneurysm versus a congenital web in the innominate artery (left arrow). The anomalous origin of the left carotid artery is also seen (right arrow).

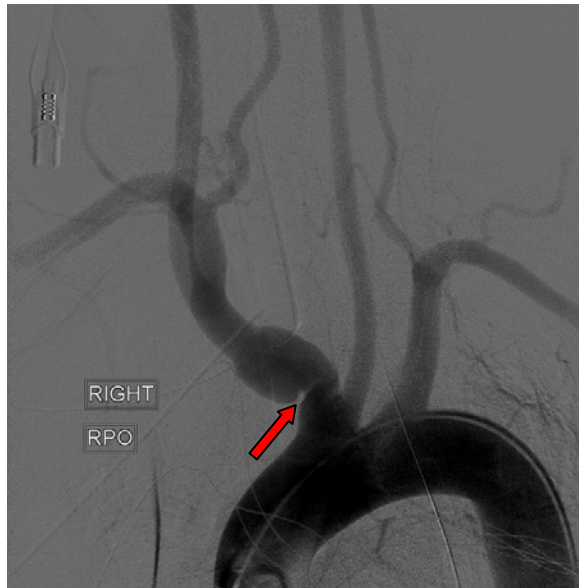


Figure 4. Arteriogram confirming a focal arterial injury (arrow) with pseudoaneurysm in the left innominate artery. The arterial injury is 1 cm distal to the takeoff of the anomalous left common carotid artery and terminates approximately 2 cm proximal to the origin of the right common carotid artery.

Based upon these findings, an off-pump repair with exclusion and bypass of the innominate artery injury was planned. A median sternotomy with extension to the right neck allowed for exploration and delineation of the great vessels. Intraoperatively, significant sternal disruption required complex wire closure at completion. A hematoma was found throughout the fat pad and overlying the innominate artery and anomalous origin of the left carotid artery. The hematoma correlated to the partial transection of the innominate artery. The origin of the left carotid was identified at approximately 1 cm proximal to the partial transection. The area of vascular disruption extended distally to within 2 cm of the bifurcation of the right carotid and subclavian arteries. The innominate vein was preserved.

The patient received heparin (12,000 units) and a side-biting clamp was placed on the ascending aorta. A #10 Hemashield interposition graft (Meadox Medicals, Inc.

Oakland, NJ) was anastomosed to the ascending aorta and the innominate artery distal to the origin of the anomalous left common carotid. Antegrade flow was preserved through the left carotid artery throughout the case.

We evaluated collateral circulation prior to division to ensure cerebral perfusion. The proximal stump of the innominate artery was oversewn with continuous 4-0 polypropylene suture. The free end of the graft was anastomosed end-to-end to the distal innominate artery beyond the injury with continuous 4-0 polypropylene suture. We utilized weave repair of the sternum for closure. After an uneventful postoperative course, the neurologically-intact patient was discharged home after seven days.

## Discussion

Blunt injury to the innominate artery is rare. The main etiologies are motor-vehicle crash, crush injury, or fall.<sup>2</sup> The incidence of an anomalous origin of the left common carotid from the innominate artery is between 10-27% of the general population.<sup>1,4-9</sup> Twenty-nine percent of patients who have innominate artery disruption exhibit this anomaly.<sup>1,7</sup> Depending on the incidence of the anomaly in the general population, the percentage of patients who have an innominate artery injury in the setting of the anomaly may be a reflection of its incidence in the general population, or the anomaly may predispose one to an innominate artery injury. In the latter case, the anomalous anatomy of the innominate artery may render it susceptible to injury as a result of the decreased number of fixation points in the aortic arch. When the aortic arch suddenly becomes compressed between the sternum and spine with the neck hyperextended, the energy then is concentrated on the takeoff of the innominate, resulting in a tear or transection.<sup>5</sup>

Eighty-seven percent of innominate artery injuries display a widened mediastinum on chest radiograph.<sup>2</sup> A widened mediastinum, loss of aorto-pulmonary window, loss of aortic knob, or suspicion of a thoracic vascular injury by mechanism should lead to a CT scan of the chest. In the current case, the patient exhibited the first three of these conditions. If a mediastinal hematoma is noted on CT, the patient should undergo an angiogram to rule out injury of the aorta or major branches.<sup>2</sup>

Once an injury to the innominate artery is diagnosed, surgery is the standard treatment, although stenting also has become an option depending on the site of rupture and the operator's experience.<sup>10</sup> In our case, stenting was not an option as a stent repair of the innominate artery would have led to the occlusion of the anomalous left common carotid artery. Timing of the surgery for innominate artery repair is usually urgent, but if the patient has multiple concomitant injuries, repair may be delayed with medical management by maintaining the mean arterial pressure less than 70 mmHg.<sup>3,11-13</sup> A median sternotomy with or without extension along the lower anterior border of the right sternocleidomastoid muscle is the incision of choice. The repair is commonly done by the bypass exclusion technique, without shunting or cardiopulmonary bypass.<sup>3,14-16</sup> Reported long-term patency rates of aorto-innominate artery bypass is high with greater than 96% patency at 10 years.<sup>2,15</sup>

The repair may be performed under profound hypothermia with circulatory arrest<sup>1,17,18</sup> or with cardiopulmonary bypass either with or without selective perfusion of the common carotid artery or retrograde cerebral perfusion,<sup>12,19</sup> with the use of external or internal shunts,<sup>5,8</sup> or by repairing the injury with or without measurement of the carotid artery stump pressure, ideally greater than 50 mmHg.<sup>3</sup> The goal is to

protect cerebral perfusion. Approximately 90% of cerebral blood flow comes from the carotids with the remaining 10% supplied by the vertebrals.<sup>3</sup>

In patients with an anomalous left common carotid artery, cerebral perfusion becomes more complex during clamp repair as the left vertebral artery may provide the only cerebral perfusion after clamping. In our case, initial CT understated the complexity of the injury and angiography was useful for confirmation. The arteriogram also allowed for surgical planning. Secondary to the nature of the patient's anatomy and location of injury, left carotid perfusion was preserved during repair and perfusion to the cerebral vessels were monitored indirectly by intraoperative pressure monitoring from the bilateral upper extremities.

Associated injuries are common with blunt injury to the innominate artery and include other major vascular, thoracic, head, cervical spine, and facial injury, as well as long bone fracture.<sup>2</sup> If cardiopulmonary bypass is required, one also has to keep in mind the risks of full heparinization in patients with head or abdominal injuries. The method of repair also will be individualized based on other associated

major vascular injuries that exist in a particular patient.

### Conclusion

Successful bypass and exclusion of the pseudo-aneurysm was performed without cerebral compromise and without cardiopulmonary bypass. This was possible due to the lack of any other major vascular injury, lack of brain injury, and the nature of the patient's injury (the innominate artery injury being distal to the anomalous origin of the left carotid artery off the innominate artery). Ultimately, the treatment of a patient with innominate artery injury should be individualized to take into consideration other existing major injuries and location of the lesion. In the face of an anomalous branching pattern of the aortic branches, special consideration should be taken to preserve cerebral perfusion secondary to the anatomic structure where three of the cerebral vessels originate from the first branch point of the aorta.

By identifying the characteristics of the patient's injuries, we achieved a successful repair via bypass and exclusion of a blunt, partially transected innominate artery without cerebral compromise and cardiopulmonary bypass.

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