



Endovascular Repair of Traumatic Aortic Pseudoaneurysm and Delayed Presentation of Pericardial Rupture with Cardiac Herniation in Pediatric Trauma

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Abstract

We present the case of a 14-year-old healthy boy who presented after being a restrained back seat passenger in a single motor vehicle accident. He was found to have a thoracic aortic pseudoaneurysm which was managed with placement of an endovascular stent graft. Initially he recovered, then experienced a syncopal episode, and on repeat imaging was found to have a pericardial rupture with cardiac herniation. He underwent open repair of his pericardium and recovered uneventfully. Thoracic aortic pseudoaneurysm and pericardial rupture with cardiac herniation, represent rare potentially life threatening intrathoracic injuries that must be considered and appropriately treated when evaluating pediatric thoracic trauma.

OPEN ACCESS

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Received Date: 28 Jul 2016

Accepted Date: 17 Sep 2017

Published Date: 11 Oct 2017

Citation:

Hetherman D, Malka K, Schanzer A, Wallace EC, Kane D, Breitbart R, et al. Endovascular Repair of Traumatic Aortic Pseudoaneurysm and Delayed Presentation of Pericardial Rupture with Cardiac Herniation in Pediatric Trauma. *Clin Surg*. 2017; 2: 1673.

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Keywords: Pediatric trauma; Cardiac herniation; Endovascular repair

Case Presentation

Our patient, a 14-year-old otherwise healthy boy, presented to University of Massachusetts Medical Center as a transfer from an outside hospital after being the restrained backseat passenger in a motor vehicle accident. His initial assessment showed a blood pressure of 102/60 mmHg, a heart rate of 80 bpm, and an oxygen saturation of 100% on 2 liters of nasal cannula. He had a Glasgow Coma Score of 15. His physical exam was notable for a right clavicle deformity, a seat belt sign across his chest and abdomen, and moderate upper abdominal tenderness without peritonitis. Focused Assessment with Sonography for Trauma was positive in the left upper quadrant which was consistent with splenic injury visualized on a CT scan obtained at the transferring hospital.

Chest X-ray during the initial assessment showed a right clavicle fracture and a left 9th rib fracture. Given the degree of chest trauma, a CT chest with IV contrast was performed and carried down through the upper abdomen for additional comparison to the prior CT scan of the abdomen and pelvis. This demonstrated a grade 3 thoracic aortic pseudoaneurysm arising just distal to the origin of the left subclavian artery (Figure 1) bilateral pulmonary contusions, and a left pleural effusion. Additionally, the abdominal imaging uncovered a significant increase in the size of a mesenteric hematoma, a grade 3 spleen laceration, and a grade 1 renal laceration. Vascular Surgery was consulted and, in conjunction with Pediatric Surgery, the patient was taken emergently to a hybrid operating room. Vascular surgery performed a right femoral cut-down, aortic arch angiogram (Figure 2), and deployed a Cook[®] alpha thoracic endograft device measuring 20 mm x 105 mm. To exclude the pseudoaneurysm, the endograft was positioned just distal to the left carotid artery, thereby intentionally covering the left subclavian artery. A completion arch angiogram was performed (Figure 3) which demonstrated complete exclusion of the pseudoaneurysm. In addition, an abdominal aortic angiogram was performed which demonstrated no active extravasation of contrast. The patient remained stable but, given the increased size of this mesenteric hematoma on

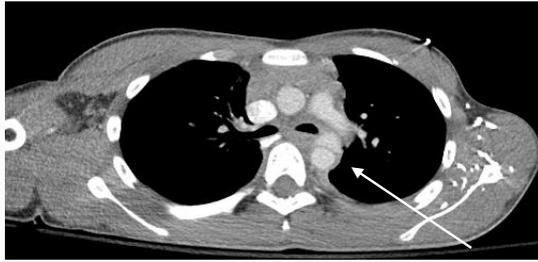


Figure 1: Admission CT Scan showing aortic pseudoaneurysm distal to the take off of the left subclavian artery.

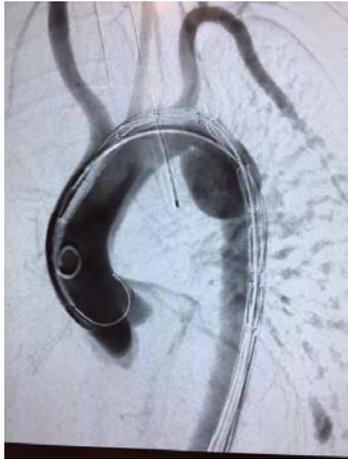


Figure 2: Intraoperative aortogram demonstrating the aortic pseudoaneurysm.



Figure 3: Completion aortogram demonstrating the exclusion of the pseudoaneurysm.

repeat imaging, a diagnostic laparoscopy was performed. A hematoma was noted in the transverse mesocolon, however, all examined bowel was viable and there was no evidence of active bleeding from any other abdominal source.

Postoperatively, our patient’s initial recovery was uncomplicated and his diet was advanced with return of bowel function. During that initial recovery, a troponin was sent to evaluate for cardiac injury and was increased (0.57 ng/mL). This prompted echocardiography that showed a large left pleural effusion and mild biventricular systolic dysfunction from a presumed cardiac contusion. There was no pericardial effusion was noted and the troponin leak resolved over a



Figure 4: Admission CT scan (top) showing the normal position of the apex of the heart (white arrow). Follow up CT scan on the (below) showing displacement of the heart apex into the left chest consistent with pericardial rupture (white arrow).



Figure 5: Cardiac subluxation through the pericardium. Edge of pericardium is demonstrated with the white arrows.

few days and he was discharged on post trauma day seven.

One week after his discharge, the patient experienced a syncopal event prompting additional workup. A CT angiogram of the chest abdomen and pelvis revealed a well positioned thoracic endograft with no evidence of leak or rupture and no new abdominal pathology. However, the heart was now oriented more posteriorly and leftward, with “ghosting” artifacts present in the descending aorta secondary to transmitted left ventricle contractions (Figure 4). This finding was felt to represent cardiac displacement and was similar in appearance to congenital absence of the pericardium. This change in cardiac position and orientation raised the possibility of a pericardial rupture with cardiac herniation. The patient was referred to a high volume cardiac surgical center for further diagnostics and consideration. Video-assisted thoracoscopy was performed and confirmed rupture of the pericardium and cardiac displacement into the left pleural space (Figure 5).

Although there was no evidence of strangulation of the great vessels, pulmonary venous obstruction or compression of the coronary arteries at the time of the thoracoscopy; the uncertainty about these risks developing in the future led to the decision for operative repair. A left thoracotomy was performed with the patient placed in the right decubitus position. The pericardial rupture was in a vertical plane and spared the phrenic nerve. The edges of the pericardium were mobilized and repaired with the use of a bovine

pericardial patch. Once the pericardial space was closed, the heart was returned to its normal anatomic position. Six months after his trauma, he is doing well and has returned to his baseline function and sports participation.

Discussion

Trauma continues to be a leading cause of morbidity and mortality in the pediatric population. The patient presented in this case report highlights two rare intrathoracic injuries, both of which can lead to devastating outcomes. Blunt thoracic aortic injury occurs in approximately 0.1% of traumas and carries with it a mortality rate of more than 40% [1]. Similarly, blunt pericardial rupture is primarily a postmortem finding, and was found in only 17 patients in a retrospective review of 20,000 trauma patients [2]. Both these injuries are rare, often fatal, and each has their own diagnostic and therapeutic considerations in the pediatric trauma population.

Thoracic aortic injuries typically result from rapid deceleration; however, there is no evidence to suggest that seat belt use increases the incidence of thoracic aortic injury [3]. Blunt thoracic aortic injuries are graded based on the severity of injury: grade 1 injuries are intimal tears and hematomas; grade 2 injuries are intimal injury with periaortic hematoma; grade 3 injuries are transections with pseudoaneurysm formation, and grade 4 injuries include free aortic rupture. Management of adult aortic injuries has shifted toward endovascular repair in patients who are stable enough to obtain imaging and have a grade 3 or 4 injury. Operative repair is also indicated in those lower grade injuries with associated traumatic brain injury thus precluding non-operative management due to the need for increased cerebral perfusion [4]. Traditionally, more severe grade blunt aortic injuries in children have been repaired in an open fashion, with or without the assistance of cardiopulmonary bypass. These repairs have had variable degrees of success with mortality rates ranging from 0% - 40% in various series, with complications including paralysis, pulmonary embolism, renal failure and recurrent laryngeal nerve injury [5,6].

However, since the early 2000s, there have been an increased number of endovascular repairs reported in children. [5-9]. Endovascular repair offers a minimally invasive approach but is not without significant considerations in the pediatric population. The growing patient and vessel may predispose to endovascular leaks as a patient continues to grow and may necessitate additional re-interventions, although we are not aware of any reports of re-interventions to date. Additionally, the need for long term surveillance imaging with CT scans does pose a significant radiation exposure over the lifetime of a pediatric patient. Despite these challenges, endovascular repair is becoming the more common approach and has been used in children as young as 16 months old [7]. Endovascular repair appears to carry less risk of morbidity than open repair, however limited data exist. Treatment algorithms for adolescents with blunt aortic injury have been proposed with endovascular repair suggested for grades 3 and 4 injuries [5]. We feel that endovascular repair should become the first line treatment in children due to the decreased rates of significant surgical complications. However, we do recognize the need for more long term follow up data to fully evaluate the impact of these repairs in both children and adolescents.

While endovascular repair of blunt aortic injury is becoming more common in the pediatric trauma population, delayed presentation of blunt pericardial rupture with cardiac herniation has not, to our

knowledge, been reported in the pediatric trauma literature. Blunt pericardial rupture is a rare injury in adult trauma patients, with only 17 cases of isolated pericardial rupture found over 10 years in a review of 20,000 adult patients. Based on this review, approximately 64% of pericardial ruptures were into the left pleural cavity, with 18% being through the diaphragm, 9% into the right pleural cavity, and 9% involving the superior mediastinum. This series described just 6 cases of associated herniation of the heart through the pericardium, with 5 being into the left pleural cavity. When cardiac herniation is found, death can occur due to torsion or incarceration of the great vessels with ensuing loss of cardiac output [2].

The diagnosis of pericardial rupture remains challenging. Chest x-ray showing displacement of the heart or pneumopericardium can be used to help diagnosis pericardial rupture, but the diagnosis still requires a high degree of suspicion. While the wide use of CT scan imaging can significantly increase the detection of pericardial injuries, not all patients with pericardial injuries have findings on initial imaging, as is the case with our patient. Physical exam may reveal a "bruit de moulin" or waterwheel splashing murmur, although that is clinically difficult to detect and was not noted in our patient. [2,10-14]. Late presentations are rare but have been reported [12]. In these reports and in this case, echocardiography can be non-diagnostic. The change in cardiac orientation that occurs with subluxation may not manifest until a patient becomes ambulatory and the heart is more influenced by gravitational effects. This diagnosis should be considered strongly in a pediatric patient with blunt trauma severe enough to result in aortic injury.

Treatment for pericardial rupture with cardiac herniation is surgical in most cases due to the high mortality rates [2]. In cases with cardiac herniation, surgical repair should be undertaken expeditiously to prevent torsion of the great vessels as well as coronary artery compression. This has been approached both thoroscopically or with an open approach in various reports. The principals of the operations are that the heart should be returned to the mediastinum and the pericardium repaired when feasible. When pericardial injuries are found that are too small to allow cardiac herniation, these injuries could be left unrepaired as the surgical risk for pericardial or myocardial injury may be greater than the benefit of closure [2,10-17].

Conclusion

This case highlights two rare intrathoracic injuries that must be considered in the evaluation of the pediatric trauma patient. In the setting of blunt aortic trauma, we are in the midst of a paradigm shift where most of these injuries can be treated with a minimally invasive endovascular approach. Early data suggest that an endovascular strategy is associated with a significant reduction in morbidity and mortality compared to open repair. Pericardial injuries with cardiac herniation occur much less frequently, but when recognized, must be fixed expeditiously given the potential devastating outcome if great vessel incarceration or coronary artery compression occurs. While it is possible that the seat belt restraint played a role in the etiology of our patient's injuries, it is important to note that it did likely prevent any associated severe head injury from this high velocity motor vehicle injury event.

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