Occult Aortic Rupture Related to Blunt Thoracic Trauma: A Review of Current Literature

Künt torasik travmalara bağlı meydana gelen aort travması: Güncel literatürün yorumu

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SUMMARY

Organizing prospective clinical studies on blunt aortic trauma patients has been challenging. This review aimed to discuss blunt aortic trauma via a case in the light of the literature. It sparked a literature search for current evidence in the initial diagnostic modalities and algorithm in the management of patients with stable blunt traumatic aortic injuries.

Key words: Blunt aortic trauma.

ÖZET

Künt aort travmalı hastalarda ileriye dönük çalışma organize etmek zordur. Bu derleme makalesi bir olgu sunumu aracılığı ile literatür ışığında künt aort travmaları tartışmayı amaçladı. Stabil künt aort travmalı hastalar yönetiminde başlangıçtaki tanısal modaliteler ve algoritimler güncel bilgilerin ışığında sunulmaya çalışıldı.

Anahtar sözcükler: *Künt aort travması.*

Introduction

Blunt aortic trauma is an infrequent but not rare pathological entity. World Health Organization case reports indicate that the thoracic trauma is responsible for 25% of deaths caused by traumatic thoracic injury, second only to head trauma.[1] Currently there are protocols on the investigation of patients who has sustained blunt thoracic injury and are unstable or have significant findings in the chest radiographs. However there are no clear guidelines on the investigation and management for a subgroup of patients who have sustained blunt thoracic trauma and are stable with no chest radiograph findings. Signs and symptoms in are blunt thoracic injury are unreliable and can be obscured by other injuries that are more apparent. This poses a challenge for any practicing emergency physician. This task is further complicated when, a patient, after a blunt injury to the chest, appears well and has minimal complaints. The following is such a case with aortic injury that was missed initially but, fortunately, the patient had a good outcome. It sparked a literature search for current evidence in the initial diagnostic modalities and algorithm in the management of patients with stable blunt traumatic chest injuries.

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Case

A 55-year-old man was brought to the emergency department with epigastric pain and vomiting. Five days earlier, he was involved in a road traffic accident when he skidded on a motorbike and sustained a right upper limb fracture. He was seen at another emergency department and had a chest radiograph done for chest trauma, which was reported as normal. He was admitted to that hospital for open repair of fracture distal radius and was discharge 3 days later, well. However he continued to complain of niggling chest pain.

On arrival at the emergency department, he was alert and orientated but cold and clammy. His blood pressure was 70/53 mmHg and pulse rate was 95/min. There was epigastric tenderness but no rebound nor guarding. Heart and lungs were clear. Per-rectal exam showed no malenic stools. His hemoglobin was 9.4 g/dL. An initial chest radiograph showed enlargement of the heart shadow, unfolding of the aorta and opacification of the left middle and lower zones compatible with a pleural effusion. Computer tomography of the chest and abdomen revealed an isthmic pseudoaneurysm of the aortic arch, and a large amount of high-density fluid in the left pleural space, consistent with a haemothorax that suggested a chronic leak likely from the pseudoaneurysmal sac.

The patient was given fluids resuscitation and sent to the operating theatre for suspected aortic rupture. The chest was opened via left thoractomy and the haemothorax was evacuated. There was a transaction in the medial wall of the post subclavian aorta, and the defect measured 3 cm in diameter. A large pseudoaneurysm was found at the aortic isthmus and was resected. Anastomosis was constructed with a #20 Gelseal aortic graft.

The patient was sent to intensive care unit after the operation and was later discharged well from the hospital.

Similar cases

A literature search was done using the keywords “chest”, “thoracic”, “trauma”, “injury”, “aortic” and “delayed”, for cases with stable blunt chest injury and later presented with deterioration. It yielded other reported cases with similar presentation as above. The cases are tabulated below in Table 1.[2-9]

These are some examples of reported cases in the literature that were published. It is possible that an equal or more number of cases which were not published or discovered only at autopsy. We want to identify this special subcategory of patients who presents stable initially but deteriorate over the hours or days after the blunt chest trauma.

Pathophysiologic Process and Mechanism of Injury

Mechanism of injury remains the most important factor in establishing the diagnosis, falls from 10 feet, motor vehicle crashes at speeds 30 mph, unrestrained drivers, ejected passengers, and pedestrians struck by motor vehicles are some guides commonly used to determine the management of these patients. Blunt trauma can damage the thoracic aorta by direct mechanisms, a displaced thoracic vertebral fracture can cause shearing injury to the aorta. Bony intrusion by the first rib and clavicle can cause ‘‘osseous pinch’’ or bony compression of the aortic isthmus.[14,15]

Indirect forces can also damage the aorta. The most commonly cited reason of rupture is the differential forces (traction, torsion and hydrostatic) set up within the chest by deceleration in either the horizontal or vertical plane. Intraluminal hypertension occurs within the aorta at the moment of impact (water hammer effect) and rupture results.[16,17]

Relatively mobile sections, the heart and ascending aorta swing forward and move in relation the descending aorta that remains fixed to the posterior chest wall, resulting in the tear at the isthmus. Among the aortic injuries, 96% occur at the aortic isthmus distal to the left subclavian

Table 1. *Characteristics of the cases.*

Sex, age	Mechanism	Presenting symptoms	X-ray	Interval to diagnosis	Outcome
Male, 34[2]	MVA	Back pain	Normal	7 days	Survived
Male, 45[3]	MVA	Anterior chest pain and dysphagia	Normal	7 days	Survived
Male, 26[4]	MVA	Precordial pain that radiated to the neck and was exacerbated by movement	Normal	49 days	Death
Male, 21[5]	MVA	Hoarseness of voice	Abnormal	On time	Survived
Female, 64[6]	MVA	Nil	Abnormal on preoperative testing	Slight delay	Survived
Unkown[7]	Not available	Nil	Normal	21 days	Death
Female[7]	Not available	Nil	Normal	56 days	Death
Female, 20[8]	MVA	Nil	Normal	20 days	Survived
Male, 52[9]	MVA	Distracting injuries present	Normal	3 days	Survived

artery, 1% at the aortic isthmus and proximal ascending aorta, 1% at the proximal ascending aorta only, 1% at the distal ascending aorta only, and less than 1% at the descending aorta. The most common sites of arterial injuries are aortic rupture alone (81%), aortic arch branches alone (16%), and both aorta and aortic branches (3%).[19]

With this understanding, we are able to explain why there are consistencies in the injuries sustained.

In his landmark paper in 1958, Parmley looked at 296 cases of blunt aortic injury among young soldiers and found that about 15% survive long enough to get to hospital. 85% of victims die at the scene of the accident or within 30 mins if arrival at the hospital.[10]

Of the surviving patients, 20% will die within 6 hours, 30% within 24 hours, 75% within eight days, and 90% within four months.[45] Without treatment, 2% survive to develop a chronic pseudoaneurysm. The aortic isthmus was also found to be by far the most common site of rupture.[10,18]

A traumatic pseudoaneurysm is formed in survivors, an intact adventitial layer and the formation of a hematoma. The lesion, an intimal/medial tear, may partially involve the aortic surface with possible subsequent formation of a diverticular aneurysm; the intimal tear may also be circumferential, causing a fusiform aneurysm with possible invagination of the aortic lumen[11,12] Ayella et al. reported a series of 36 traumatic aortic rupture, 60% of which only involve intima and media, leaving adventitia intact resulting in delayed rupture.[13] Tears begin in the intima and progress outwards through the media and adventitia. There are some rare reports of long term survivors in the literature during the times when surgical intervention was not the normal management.

To date, much technology and time has been invested into making vehicles safer for the driver and passengers. Aortic injury as a result of blunt trauma is most commonly seen after severe deceleration in high-speed motor vehicle crashes.[10,25] Studies comparing injured drivers from non air bag vehicles, injured drivers from air bag deployed vehicles incur proportionally less head injuries and proportionally more arm injuries. The favorable head injury result arises most directly from a reduction in fractures. However, there is no trend on the influence of the air bag on the spine, chest, abdomen, or legs that could be identified.[21] John H. Siegal et al. found that seatbelts and airbags deployment plays a role in preventing scene death and allowing the patient with aortic injury to reach the hospital alive, especially for those involved in lateral collision, and does not appear to affect the incidence of blunt aortic injury.[20,22] This results in an increasing number of patients brought to the emergency department, surviving the initial impact with minimal physical signs of injury on the chest but has significant blunt chest trauma. A high index of suspicion is therefore required in the emergency department in order to diagnose thoracic aortic injury as the initial chest X-ray may be normal and external evidence of injury may be minimal or absent; especially if the accident occurred with deployment of an airbag.[23,24]

Time of Injury to Rupture

Similar to the cases mentioned in our article, many authors have reported that majority of these aneurysms do eventually rupture but the timing is unpredictable (ranging from months to several years).[28,29] The considerable variability of progression is probably explained by the extent of involvement of the aortic wall and the development of post-traumatic aneurysm, which can range from 29 to 123 hours after admission.[27]

The incidence of interval rupture remains real, at least 5-10% in the first 24 to 48 hours of admission. Torreggiani et al. demonstrated the evolution of a CT scan diagnosed mediastinal hematoma in a patient being transferred to another hospital for treatment within 5 hours.[26] There are also reports which document cases remaining “stable” for years.[30] The studies which analyze the behavior of traumatic aortic ruptures in the subacute phase and investigates selective delayed management of aortic injuries for patients with aortic injuries,[31-33] highlights the existence of this group of patients whom are easily missed at the point of initial consultation because of paucity of signs and symptoms, that are stable initially, but will eventually deteriorate without further intervention. Delay in diagnosis results in increased morbidity and mortality.[34-36]

Clinical Signs and Symptoms

The protean nature of signs and symptoms in patients who sustained blunt aortic injury makes clinical suspicion difficult. Symptoms are often non-specific. The most common physical findings in these patients are pseudo-coarctation and intrascapular murmur.[37-40] The absence of these signs does not exclude blunt aortic injury.[41,42]

Investigations

Chest radiographic clues suggesting aortic injury[43,44] include:

- Widened (>8 cm) mediastinum
- Depressed (>140 degrees) left mainstem bronchus
- Loss of aortic knob contour
- Lateral deviation of trachea
- Deviation of nasogastric tube in esophagus
- Anterior displacement of trachea
- Displacement of the nasogastric tube to the right of the T4 spinous process
- Left apical pleura hematoma "cap"
- Calcium "layering" in aortic arch
- Massive left-side hemothorax
- Fracture of thoracic spine, clavicle, sternum, or scapula
- Loss of paraspinal stripe
- Loss of aorticopulmonary "window"

In trauma patients with a negative chest film, 3% will have occult mediastinal hemorrhage discovered at CT and 0.4% will have an aortic injury. On the other hand, 78% of patients with abnormal chest film with mediastinal widening have normal CT scans,[43] and more than 80% will have negative angiograms for aortic injury.[43,46] Predicting the presence of mediastinal hemorrhage on supine portable chest films in the setting of trauma is very inaccurate.[46] It is also important to remember that most of the plain film findings associated with aortic transection are nonspecific. They may be seen in a variety of other mediastinal or chest wall injuries including non-aortic vascular injuries (tears and avulsions of the great vessels, internal mammary vessels, or subclavian vessels); sternal fractures; thoracic spine fractures; and esophageal rupture.[44]

An erect postero-anterior view, with a sensitivity of 79% for detecting serious injuries, is better than a supine antero-posterior view, with a sensitivity of 58%.[47,48] However this has always been difficult to perform in a trauma setting.

It has also been suggested that a 45 degree reverse Trendelenburg anteroposterior chest radiograph should place the mediastinal structures in a more appropriate position and allow a more accurate evaluation than supine antero-posterior radiographs.[49] However this has not been verified in any well-designed study.

Having considered all the features of chest radiographs in patients with suspected blunt aortic injury, it is possible for aortic injury to occur in the face of a normal CXR. To date no studies have shown that these X-ray features, can confidently exclude blunt traumatic aortic injury. Patients with significant deceleration or acceleration mechanisms should undergo this screening test anyway.[44,50,51] Since CXR is a routine investigation for all chest trauma patients as part of trauma protocol, one must be aware of its limitations in diagnosing occult thoracic injuries.

The MRI remains a tool for follow up of patients being treated conservatively. It is noninvasive, allows a comprehensive diagnosis in <30 minutes, and provides the complete and accurate anatomic detail necessary to assess lesion severity.[30] However cost is a prohibitive factor in using MRI as a screening tool. Furthermore, motion artifacts may mimic dissection, and MRI is technically limited by many factors such as pacemakers and metallic foreign bodies.[57,58] It may only be performed in the stable patient[30] and is useful to assess chronic traumatic aortic pseudoaneurysm.[30,57]

The role of TEE in acute presentations belong to the realm of unstable patients, unable to go for CT scan of the thorax[59] and it requires specific training and expertise.[60] It is also not so readily available as CT scan and it does not visualize the ascending aorta or the aortic branches well and may miss injuries to these vessels.[19]

Aortography remains the diagnostic standard for detecting aortic injury. Aortography establishes the diagnosis, defines the anatomy of the lesion, identifies additional sites of aortic injury and is better than other investigations for detecting supraaortic vessel injury.[61] Aortography is invasive, involves administration of radiologic contrast, time consuming and has an associated mortality of 0.03%.[58] Aortography will not be a diagnostic modality of choice for screening stable patients with low probability of sustaining aortic injury.

CT findings of aortic injury include:[52,53]

- mediastinal hemorrhage
- aortic contour deformity
- intimal flap
- thrombus protruding into the aortic lumen

• pseudoaneurym

• abrupt change in caliber of the descending aorta compared with the ascending aorta (pseudocoarctation)

• rarely contrast extravasations

Seventeen percent of aortic injuries will have only aortic contour or luminal abnormalities without significant para-aortic or mediastinal hematoma.[53]

With the advent of Helical CT has improved our ability to directly evaluate the aorta, rather than rely on indirect, less specific signs of injury such as mediastinal hematoma.

Gavant et al. used Helical CT techniques to examine 1518 patients with blunt chest trauma. 127 patients (8.3%) had abnormal chest CT scans with mediastinal hematoma and/or aortic injury. 89 of 127 patients (70.1%) showed only mediastinal hematoma, but a normal aorta. None of these patients had a positive aortogram. Using direct Helical CT evidence of aortic injury has a sensitivity of 100% sensitive and specificity of 81.7%.[54] In a review of diagnostic modalities for blunt aortic injury, Yuk[56] compared the results from large well conducted prospective trials comparing helical CT with aortography by Mirvis et al.[52] and Dyer et al.[55] and arrived at the same findings.

In a recent study by Aristomeis K et al., a retrospective review of 39 patients over a 29 year period was done and they recommend a primary routine chest CT scan in all patients with a history of motor vehicle accident (MVA) at a speed of more than 16 km/h (unrestrained) or 48 km/h (restrained) and even in cases where the height fallen was as little as seven metres.[63]

These studies supports the fact that helical CT is a reliable screening tool and now a primary initial diagnostic investigation for aortic injury in the hemodynamically stable patient with blunt thoracic trauma when read by an experienced radiologist.

Current Algorithm

Algorithms are available for the management of stable blunt thoracic injury patients and many studies investigated the need for further analysis based on the initial chest radiograph findings. This is extensively reviewed in the "EAST.Org Guidelines for Blunt Thoracic Injury."[46] However these guidelines do not take into consideration the subgroup of patients mentioned in this article and will result in a missed diagnosis of aortic rupture.

A case control study by Blackmore et al. formulated and validated a clinical prediction rule for aortic injury using age, whether the patient was restrained, hypotension , thoracic injury, abdominal-pelvic injury, extremity fracture and head injury as predictors. It was shown that with more than 4 predictors present, the probability of aortic injury is 0.3% (CI 0.11 - 0.83).[64] This has been used to select the most cost effective imaging strategy for a given patient. It is a clincial tool but we are unable to apply it to patients who are stable and do not have other injuries.

Discussion

From the literature search, we know that this group of patient do exist and it is only when they deteriorate later that emergency management is rendered, an unsatisfactory situation.

Progression of aortic injury to complete rupture can occur within hours of hospital admission. Early appropriate investigation and detection of the pathology is the key to management of this group of patient. Aortic trauma needs to be diagnosed rapidly, and the anatomic characteristics of the injuries, along with associated lesions, must be described precisely for optimal timing of surgical repair, be it immediate or delayed.

Early diagnosis allows a protocol of medical therapy, which appears to avoid spontaneous rupture of the pseudoaneurysm, to begin in the emergency department and allows the aortic repair to be done at an optimal time in regard to other injuries or chronic diseases.[36]

In addition, severe crush injury can also cause aortic rupture as part of blunt thoracic trauma.

In summary, we know that a sub-group of patients of blunt aortic injury present to the emergency department stable with an initial negative chest radiograph. Due to the small numbers, studies span over many years to investigate the presentation and management of patients with traumatic aortic injury.

Mechanism of injury appears to be the usual trigger for further investigation of patient who has sustained blunt chest trauma, however we have seen reports of aortic injury even with minimal transfer of forces and even crush injury.

From the few reported cases, chest pain, anterior or posterior, seems to be the only consistent complaint.

Clinical presentation of these patients to the emergency department has been changed by the deployment of airbag, seat belt and improved motor vehicle safety although they do not modify the pattern of blunt chest injury.

The time of rupture of pseudoaneurysm appears to be highly variable as seen in the reported cases and in the group of patients undergoing delayed management of aortic injury.

Helical CT of the chest appears to be an appropriate screening tool.

It is therefore proposed that regardless of mechanism of injury, all stable patients who sustained blunt thoracic injury and a normal initial chest radiograph, undergo a period of observation between 4 to 6 hours at the emergency department. There must be complete resolution of any symptoms, particularly chest pain or back pain before they are discharged with advice and early appointment for review of the next few days. Patients with significant distracting injuries and a mechanism involving high-energy transfers may need further investigation. Residual symptoms after the period of observation even though the patient is still stable, will require a Helical CT scan of the chest. If negative, the patient can be admitted for further observation, pending follow-up investigation.

The algorithm addresses a few issues.

The period of observation allows for clinical manifestation, if any, of delayed progression of initial aortic injury in a "safe" hospital setting. This is as opposed to admitting all patients with chest injury or discharging this group of patients. It allows monitoring of symptoms, which appears to be the only clinical clue in all the reported cases.

A CT scan of the chest only determines if further intervention needs to be started at the emergency department. The patient will be admitted for further observation and further non-emergent studies.

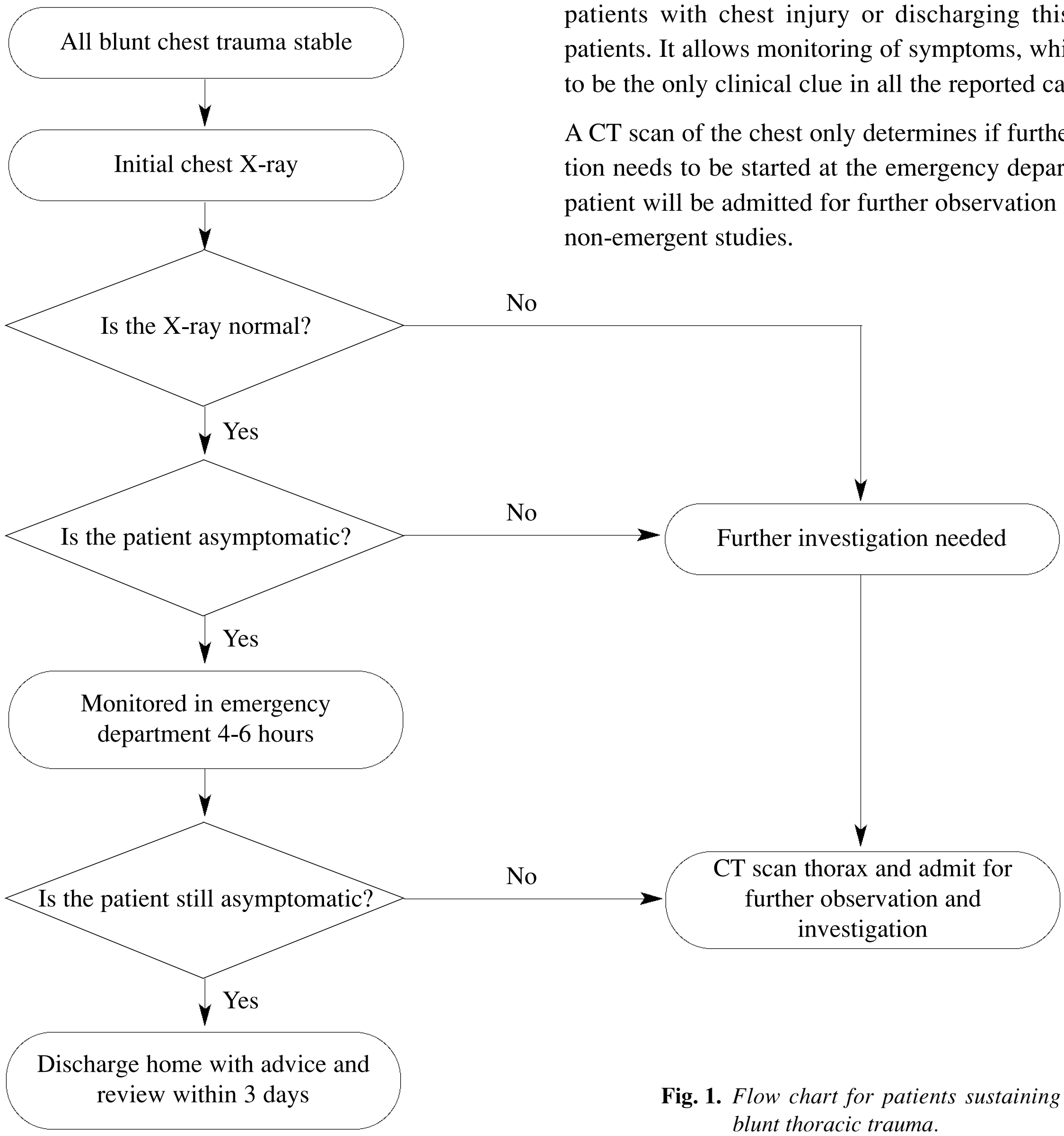

Fig. 1. *Flow chart for patients sustaining blunt thoracic trauma.*

One of the major advantages of using CT in the setting of possible aortic injury, may be in identifying other, unsuspected thoracic injuries, an issue that has plagued the management of blunt thoracic trauma for a long time.

Conclusion

It is hope that by presenting this case, reviewing the articles and proposing the management algorithm, it will increase the index of suspicion for aortic injury in patients who are stable at presentation, and allow early detection of this occult injury so that planned appropriate management can be initiated at the emergency department. By managing all stable patients with blunt thoracic injury with a defined protocol, it will serve as a platform for further prospective studies investigating the clinical predictive value of patient demographics, presenting complaint, mechanism of injury, safety characteristics of the vehicles and shed more light on the natural history of this injury. It will allow the development of a bedside clinical prediction rule for this group of patients.

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