Traumatic Deceleration Injury of the Thoracic Aorta

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A 42-year-old intoxicated male pedestrian was struck by a motor vehicle and "thrown" 45 feet. The patient did not lose consciousness. He had no specific localized pain, and was initially noted to have only minor limb abrasions. He was then admitted to the trauma center for observation. A screening CT was performed using a 16 row multidetector CT scanner. It revealed a mediastinal hematoma, and also an aortic pseudoaneurysm with an intraluminal defect at the level of the aortic isthmus (Fig. 1). A transthoracic echocardiogram (TTE) was unremarkable. Transesophageal echocardiography (TEE) was then performed to evaluate the thoracic aorta. The heart and pericardium were normal, as was the ascending and transverse aorta. When imaging the proximal descending thoracic aorta at the level of the aortic isthmus, a localized, thick, somewhat mobile, protruding intraluminal structure was noted (Fig. 2). Color flow Doppler revealed turbulent flow on both sides of this "flap." Three dimensional reconstruction images of the thoracic aorta were generated, demonstrating a spiral tear of the thoracic aorta, at the aortic isthmus (Fig. 3). Based on these findings, the patient was taken to surgery, where a spiral, subtotal, subadventitial aortic disruption (see discussion) involving three-fourths of the circumference of the aorta was found.[1,2] The tear was successfully resected and replaced with a composite thoracic graft.

Blunt traumatic chest injury (deceleration injury) most often occurs from a steering wheel injury or from a fall from a height. This may result in myocardial contusion, traumatic ventricular septal defect, tricuspid or mitral valve trauma, or injury of the aorta and great thoracic vessels. With blunt chest injury, traumatic involvement of the thoracic aorta is the second leading cause of death, after head injury.[3] This discussion focuses on deceleration related injury of the thoracic aorta.

Aortic traumatic injury tends to occur at sites of attachment. The aortic site most likely to sustain deceleration injury in patients who survive long enough to arrive to an emergency room is the aortic isthmus (95% of aortic injuries). It is located just distal to the left subclavian artery and is "attached" by the ligamentum arteriosum and spinal arteries.[4] Other potential sites of injury include: (1) the origin of the innominate artery, occurring most often from vertical falls, (2) just above the sinus of Valsalva in the ascending aorta, and (3) the level of the diaphragm.[5,6] Aortic dissection with an intimal longitudinal tear rarely is associated with trauma.[1,7,8] When rupture occurs

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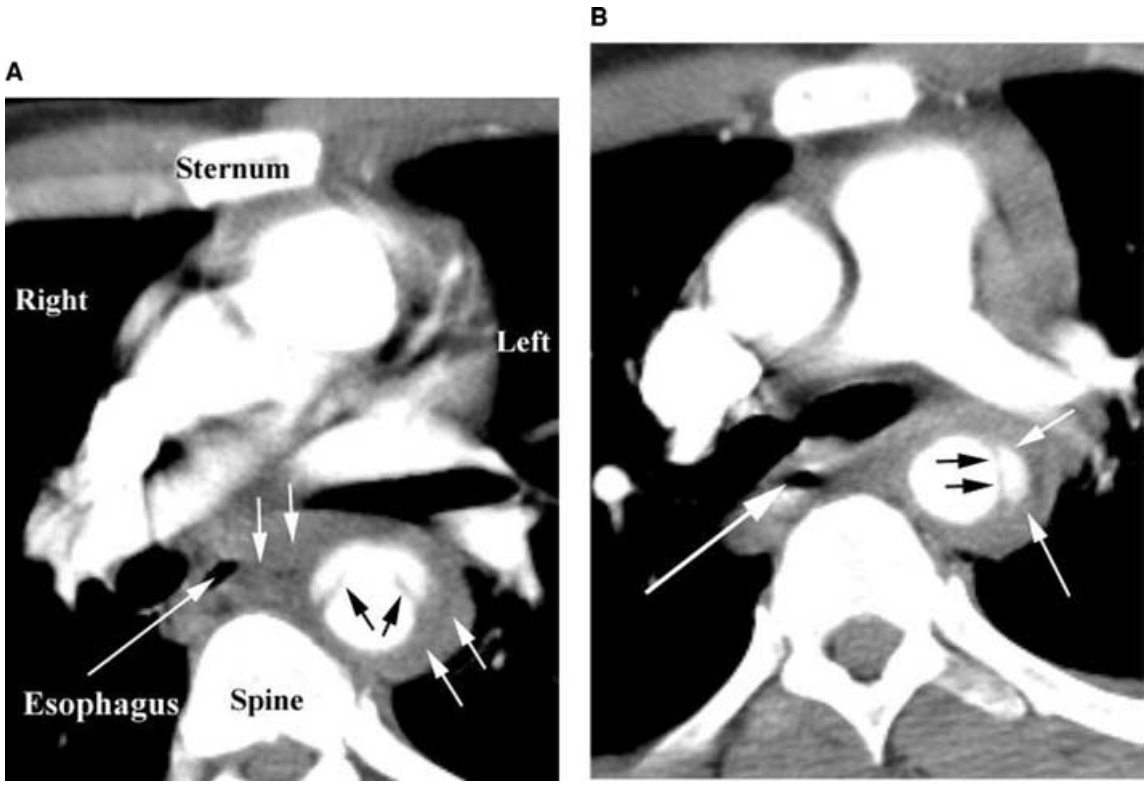

Figure 1. *Cross-sectional computed tomography (CT) with intravenous contrast at the level of the proximal descending thoracic aorta.* ***A.*** *The proximal descending thoracic aorta is noted to have two intraluminal defects (black arrows) consistent with an intima–medial flap. A mediastinal hematoma (two sets of paired white arrows) is noted surrounding the descending thoracic aorta. The esophageal lumen (arrow) is black.* ***B.*** *In this transverse cut, contrast is noted within the adventitial pseudoaneurysm (two white arrows). An intima–media tear is noted within the lumen of the aorta (black arrows). Note in these two images how the mediastinal hematoma increases the esophagus–descending aorta separation.*

above the level of the sinus of Valsalva (Fig. 4), hemopericardium and death often ensues.[6] Injury of the great vessels (innominate, left subclavian, left common carotid) and intercostal arteries may also occur, often in conjunction with aortic trauma.[9,10]

Based on an anatomic classification scheme of Parmley et al.,[11] along with TEE findings of Vignon et al.,[1,2] traumatic aortic injuries have been categorized by Vignon as: (1) traumatic aortic intimal tear (AIT), (2) traumatic aortic dissection (TAD), and (3) subadventitial traumatic disruption of the aorta (STDA). STDA is then subcategorized into three subtypes based upon anatomical involvement along with associated TEE features as: (1) subtotal subadventitial aortic disruption (sSTDA), (2) complete subadventitial aortic disruption (cSTDA), and (3) partial subadventitial disruption (pSTDA). The anatomical difference between AIT and TAD, and STDA, is that with AIT and TAD only the intima is involved, with sparing of the media and adventitia; whereas, with STDA the intima and media are disrupted, and the adventitia is preserved, forming a false aneurysm.

The incidence of AIT is probably underestimated as these are usually not visualized by aortography,[2,12,13] and it is felt that they will generally not lead to rupture, but regress with time. With this in mind, many thoracic surgeons have requested an aortogram prior to contemplating surgery in a trauma patient. If the aortogram is "normal," the surgeon would not operate. With AIT, the aortic media and adventitia remain intact. By TEE, an AIT appears as a small, thin, mobile "appendage" of the aortic wall (Fig. 5), usually within the proximity of the aortic isthmus.[1] Importantly, color flow remains laminar, as there is generally a lack of blood flow turbulence in the vicinity of the intimal tear. A mobile thrombus may be noted within the aortic lumen with AIT (Fig. 6), as the

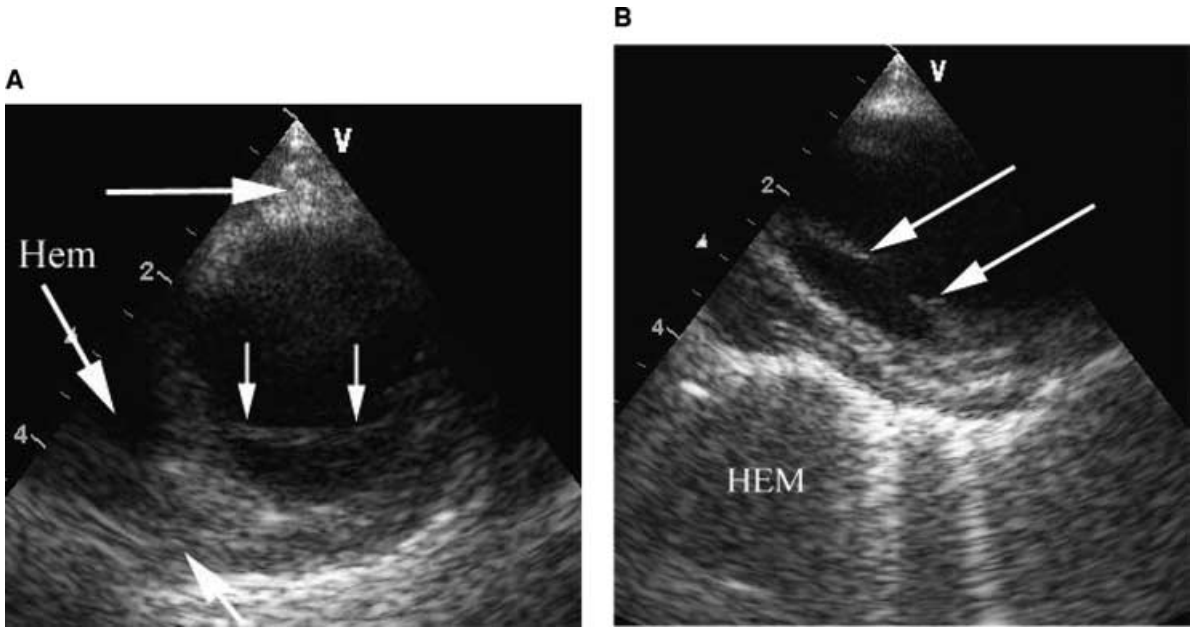

Figure 2. *Transesophageal echocardiogram (TEE) at the level of the proximal descending thoracic aorta (similar level as the CT in Figure 1) at the aortic isthmus.* ***A.*** *Horizontal plane imaging demonstrates an intima–media flap (vertical arrows). Mediastinal hematoma is noted surrounding the aorta (diagonal arrows) and between the esophagus and aorta (horizontal arrow). This image correlates with the CT of Figure 1B.* ***B.*** *At 105° the intima–media flap (diagonal arrows) appears "torn," an appearance similar to the CT image of Figure 1****A****.*

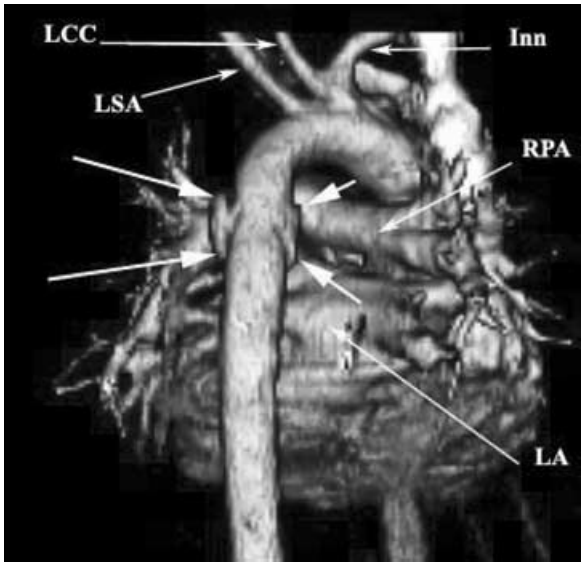

Figure 3. *Three-dimensional reconstruction image (viewed from ~15° to the right of the posterior spinal column—right posterior oblique projection) of the thoracic aorta. At the aortic isthmus a spiral tear in the intima–media layers are noted. A pseudoaneurysm is present (4 diagonal arrows). Inn: innominate artery, LA = left atrium, LCC = left common carotid artery, LSA = left subclavian artery, RPA = right pulmonary artery.*

intimal tear serves as a "nidus" for clot formation.[1,12] In comparison with aortic atherosclerotic debris, AIT is typically located at the site of the aortic isthmus and may occur in an otherwise normal-appearing thoracic aorta.

Described as occurring at any age,[14] the incidence of TAD is very low, but should be distinguished from STDA (Table 1).

With STDA 80–90% of patients die at the accident site, and of the patients that do reach a hospital emergency room, 25% will hemorrhage within 24 hours.[11,15] It is therefore important to diagnose STDA quickly, as early diagnosis and surgical repair is necessary to prevent sudden massive hemorrhage from adventitial rupture.

In distinction to acute spontaneous aortic dissection, a STDA:

1. involves both intimal and medial aortic layers,
2. is localized to a limited section of the thoracic aorta, usually the isthmus, and
3. does not create two distinct aortic channels.

To diagnose STDA by TEE, one finds:

1. disruption of the aorta within the lumen of the aorta,

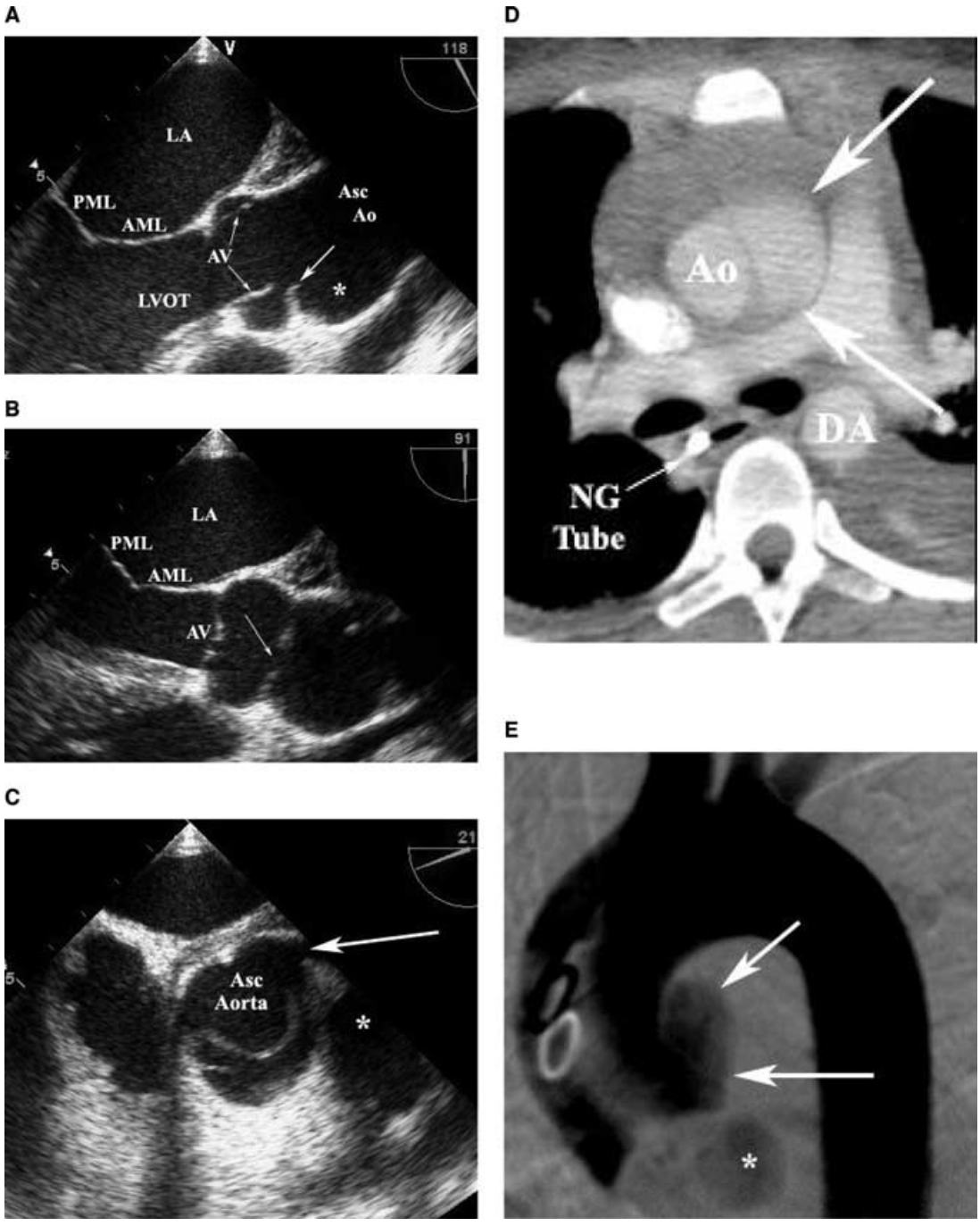

Figure 4. *During a high speed chase, an unrestrained 25-year-old female was thrown from a motor vehicle as it flipped over. Multiple orthopedic injuries were noted upon arrival to the trauma room. TEE was initially performed. A moderate-sized pericardial effusion was initially noted. The aortic isthmus was unremarkable, but the ascending aorta appeared abnormal.* ***A.*** *Imaging at 118° revealed an abnormal contour (*) of the ascending aorta (Asc Ao), above the level of the aortic valve (AV) and sinus of Valsalva. A tear (arrow) is seen at the level of the sinotubular junction.* ***B.*** *Changing the transducer to a vertical imaging angle (91°) and* ***C.*** *transverse plane through the aorta (21°) revealed a localized "tear" across the aorta at the level of the sinotubular junction. A possible adventitial pseudoaneurysm (*) with its mouth located just anterior and superior to the left main coronary artery (arrow) was considered.* ***D.*** *Computed tomography revealed the pseudoaneurysm (arrows) adjacent to the proximal ascending aorta (Ao). The descending aorta (DA), and a nasogastric tube (NG Tube) within the esophagus are also noted.* ***E.*** *Digital subtraction angiography of the thoracic aorta from a right anterior oblique projection confirmed the presence of a pseudoaneurysm (arrows) and also aortic regurgitation (*).*

Figure 5. *Schematic of traumatic intimal tear of the aorta. The medial and adventitial layers are preserved. These lesions appear to regress with conservative nonsurgical management. By TEE, there is usually no turbulent flow noted by color flow Doppler. (Reproduced with permission from the authors of Ref. 1).*

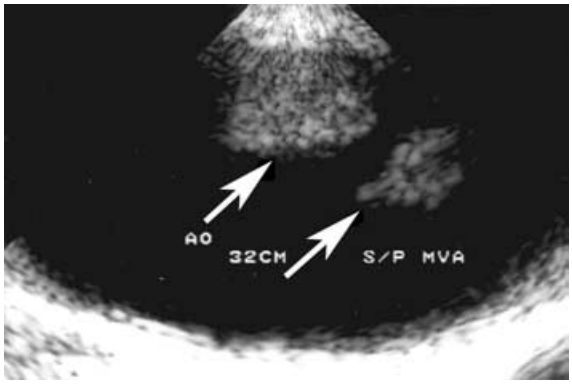

Figure 6. *TEE image of a 24-year-old unrestrained driver who bent the steering wheel upon impact. An intimal tear was evident, with the medial layer remaining intact. A mobile thrombus (arrows) was noted at the site of the intimal tear. (With permission from Kerut EK, McIlwain EF, Plotnick GD: Handbook of Echo-Doppler Interpretation, 2nd Ed, Blackwell-Futura Publishing Co., Elmsford, NY 2004, p. 226.)*

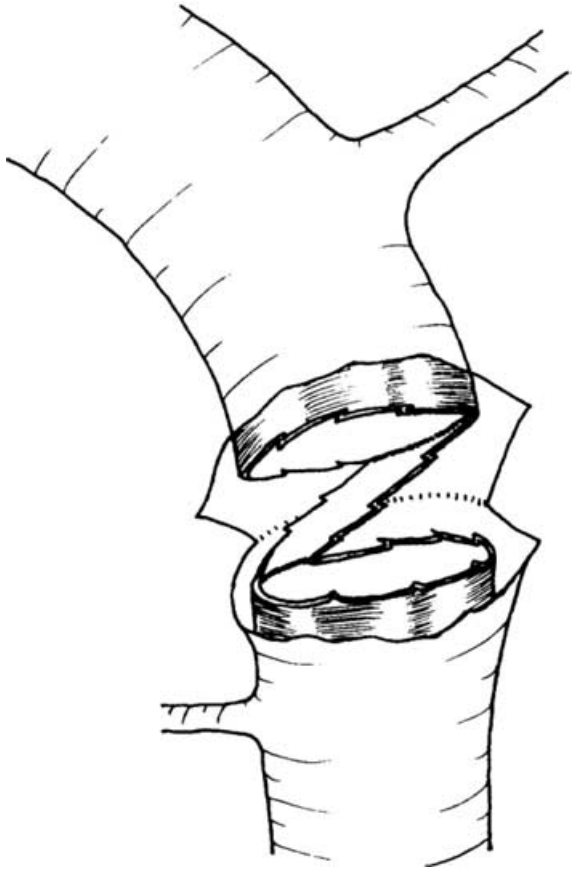

Figure 7. *Schematic of subtotal subadventitial aortic disruption (sSTDA) of the thoracic aorta, at the level of the isthmus, as visualized after incision of the adventitia. The tear typically involves at least two-thirds of the circumference of the aorta, usually in a spiral tear. (Reproduced with permission from the authors of Ref. 1.).*

2. color flow Doppler on both sides of the disruption,
3. a regional deformity of the aortic contour from a false aneurysm, and
4. at times a traumatic mediastinal hematoma is associated.

Subtotal subadventitial aortic disruption (sSTDA), as was found in the patient presented (Fig. 7), involves more than two-thirds of the aortic wall circumference, usually in a spiral tear. As the tear is perpendicular to the aortic wall at the level of the aortic isthmus, it is also perpendicular to the intimal tear of aortic dissection, which parallels the aortic wall. By TEE, transverse plane imaging reveals the tear to stretch across the aortic lumen, and longitudinal plane imaging reveals a localized tear

TABLE I

Differential Findings by TEE to Distinguish Subadventitial Traumatic Disruption of the Aorta (STDA) from Traumatic Aortic Dissection (TAD). (Reproduced with permission from the authors of Ref. 1.)

Aortic Disruption: Presence of a Disrupted Wall Traversing the Aortic Lumen	Aortic Dissection: Presence of Two Distinct Aortic Channels Separated by a Flap
Two-dimensional echocardiography:	
Transvese view	
Thick and mobile medial flap	Thin and less mobile intimal flap
Abnormal aortic contour (false aneurysm formation)	Normal aortic contour
Normal/increased aortic size	Enlarged aorta
Presence of hemomediastinum	Absence of hemomediastinum
No entry/reentry tear or thrombus	Entry/reentry tear, thrombus in the false channel
Longitudinal view	
Medial flap traversing the aortic lumen perpendicularly to isthmus wall	Intimal flap parallel to the aortic wall
Color Doppler mapping	
Similar blood flow velocities on both sides of the medial flap	Different blood flow velocities (slower velocities in the false lumen)
Mosaic of colors surrounding the disrupted wall (blood flow turbulence)	No mosaic of colors at the vicinity of the intimal flap (near laminar flow)
Location of transesophageal echocardiographic signs	
Confined to the aortic isthmus (25 to 35 cm from incisors)	More extended, according to anatomical type

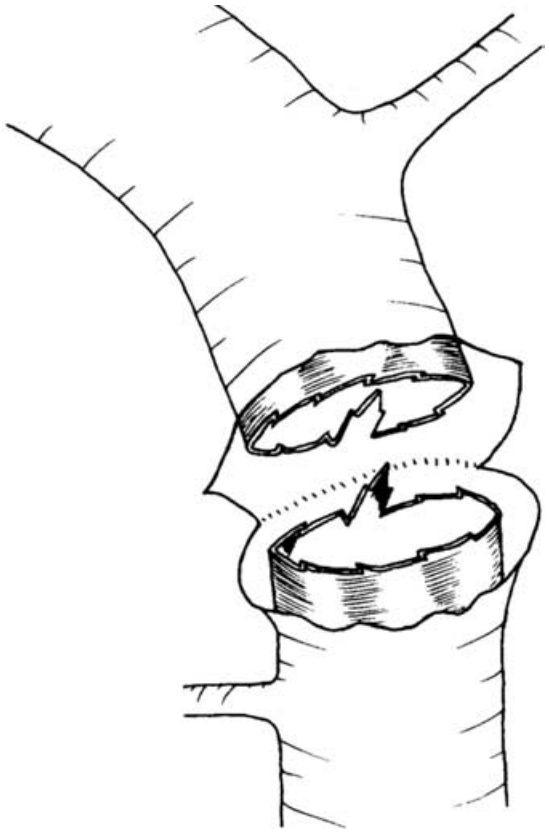

Figure 8. *Schematic of complete subadventitial aortic disruption involving the entire circumference of the aorta. (Reproduced with permission from the authors of Ref. 1).*

in the region of the isthmus, stretching across the aortic lumen. In addition, the tear is thicker than an intimal flap of dissection, as it is composed of both intima and media.

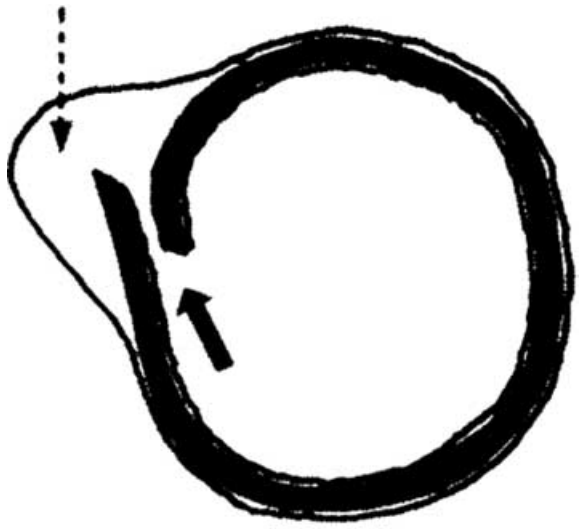

Figure 9. *Schematic of horizontal plane TEE image of the aorta at the level of isthmus. Partial subadventitial disruption involves the intima and media. A pseudoaneurysm may or may not form. If a pseudoaneurysm does form, color flow Doppler may reveal turbulent flow at that site. (Reproduced with permission from the authors of Ref. 1.)*

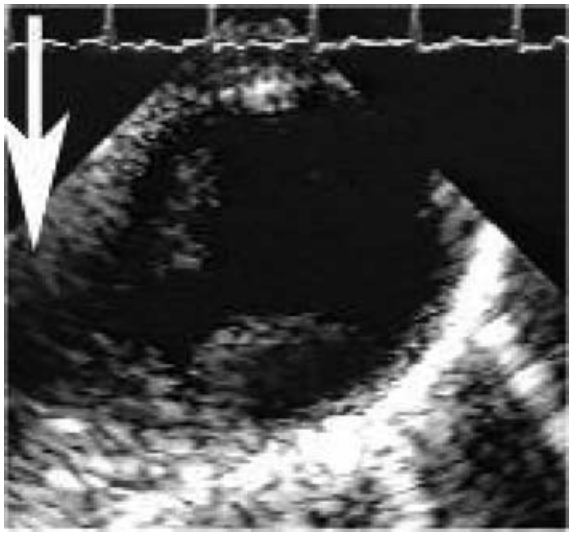

Figure 10. *TEE in a young adult involved in a motor vehicle accident. The patient was an unrestrained driver, and bent the steering wheel upon impact. Partial subadventitial disruption of the aortic isthmus with a pseudoaneurysm (arrow) was found at surgery.*

Complete subadventitial aortic disruption (cSTDA) (Fig. 8), involves the entire circumference of the aorta. By TEE, the medial flap appears as an open circle within the lumen of the aorta.

With both sSTDA and cSTDA, color Doppler reveals turbulent flow on both sides of the flap. They are most often found with an associated aortic false aneurysm, having a localized alteration in aortic wall contour.[1] While sSTDA and cSTDA may be distinguished by TEE, albeit often with some difficulty, they are both managed surgically.

Partial subadventitial disruption (pSTDA) is a limited discontinuity of both intimal and medial layers at the aortic isthmus. They may be associated with or without pseudoaneurysm formation.[16] Diagnosis may be challenging with TEE imaging (Figs. 9 and 10).

A mediastinal hematoma is often noted in blunt chest trauma with or without STDA. It is unusual to occur with spontaneous aortic dissection.[2,17] A mediastinal hematoma associated with STDA is usually larger than those associated with trauma of smaller mediastinal vessels or vertebral fractures.[18] By TEE, diagnosis of a mediastinal hematoma may be somewhat difficult. If the distance from the esophageal probe and the anteromedial aortic wall was >4mm (Figs. 1, 2, and 11), all patients in a study were found to have a mediastinal hematoma.[19]

Several concluding comments include:

1. Given the clinical context, it is important to consider thoracic aorta blunt deceleration injury, even with minimal external chest trauma. A rapid diagnosis is essential.

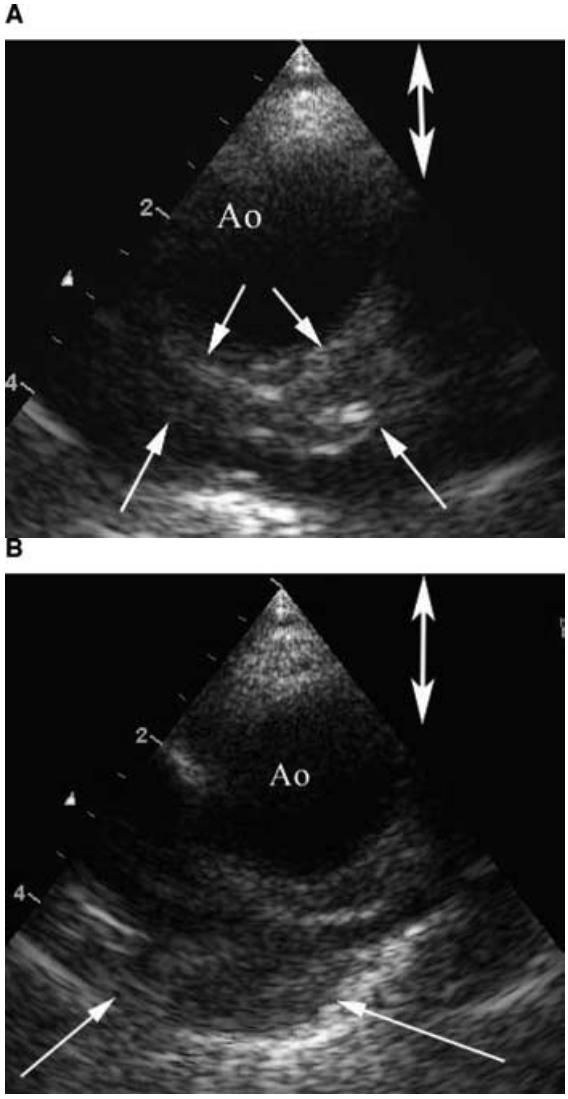

Figure 11. *TEE images and CT of the case presentation.* ***A*** *and* ***B*** *illustrate an increased distance (>4mm) from the esophageal probe to the anteromedial wall of the descending thoracic aorta (double headed arrow). This increased distance is a sign of mediastinal hematoma. Single headed arrows outline hematoma posterolateral to the aorta.* ***C.*** *CT image at a similar level as in* ***A*** *and* ***B****. A straight line demonstrates the increased distance between the esophagus (ESOPH) and the anteromedial wall of the descending thoracic aorta. Hematoma posterolateral to the aorta is also noted (HEM), corresponding to that noted in the TEE images.* *(Continued)*

C

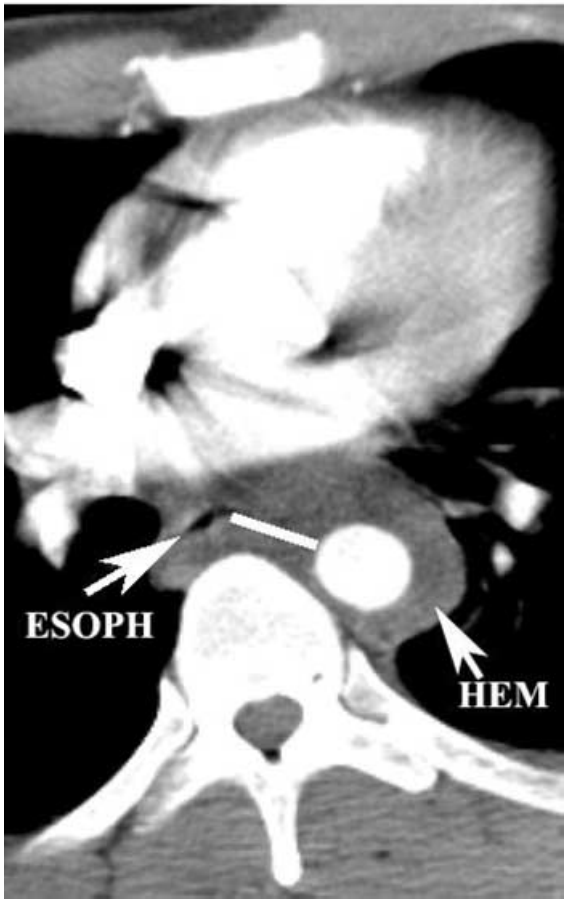

Figure 11. *Continued.*

2. Aortic trauma usually involves the area of the aortic isthmus, but may involve other vascular sites.

3. It is important to differentiate AIT from STDA.

4. STDA and acute aortic dissection have several discriminating features noted by TEE imaging.

5. It is possible to distinguish various anatomic subtypes of STDA using TEE.

6. Mediastinal hematoma is often noted with STDA. Although it may be found in trauma without STDA; when STDA is present, a mediastinal hematoma is usually larger.

7. Multislice CT imaging appears to be complimentary to TEE for diagnosis of aortic trauma.

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