Role of Transesophageal Echocardiography in Blunt Chest Trauma

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Patients who suffer blunt chest trauma are at risk for injury to the heart, and the thoracic aorta and its branch vessels. Unrecognized injury to the heart or aorta may lead to life threatening complications. Therefore, the physician caring for the trauma patient must be able to accurately and rapidly diagnose cardiac and thoracic aortic injury. Transesophageal echocardiography is an ideal tool to diagnose cardiac and aortic injury in the patient with blunt chest trauma because it provides high quality images of the heart and thoracic aorta and can safely and rapidly be performed in the emergency department, operating suite or intensive care unit. To utilize transesophageal echocardiography most effectively, the echocardiographer must be familiar with the indications, limitations, and pitfalls of transesophageal echocardiography in patients with blunt chest trauma. This review describes the role of transesophageal echocardiography in evaluating the patient with blunt chest trauma for cardiac, thoracic aortic, and mediastinal injury.

High-speed motor vehicle accidents are the most common cause of blunt chest trauma. Although rapid transport of injured patients to trauma centers and advances in the care of these patients has improved survival, injury to the heart and aorta remain the most common cause of death following blunt chest trauma. Cardiac injuries are often overshadowed by the more clinically apparent injuries to the head, lungs, abdomen, and bony structures. Cardiac injury can be life threatening and the physician caring for the patient with blunt chest trauma must be able to quickly and accurately diagnose cardiac injury.

Echocardiography is an ideal tool to evaluate the trauma patient for cardiac and aortic injury because it provides direct visualization of the cardiac structures. Transthoracic echocardiography is limited in blunt chest trauma because the chest wall injuries often preclude optimal assessment of cardiac structure and function. Furthermore, the transthoracic echocardiogram is limited in evaluating the thoracic aorta for injury. Transesophageal echocardiography (TEE) overcomes many of the limitations of transthoracic echocardiography. TEE provides excellent imaging of the heart and aorta and can be performed quickly and safely in the emergency room, operating suite, or intensive care unit. This review describes the role of TEE in evaluating the patient with blunt chest trauma for cardiac, thoracic aortic and mediastinal injury.

Transesophageal Echocardiography in Diagnosing Cardiac Injury

Cardiac injury is common following blunt chest trauma. During impact, the heart strikes the anterior chest wall leading to several types of cardiac injury (Figure 1). Blunt chest trauma can lead to myocardial, valvular, or pericardial injury. The most common cardiac injury following blunt chest trauma is myocardial contusion or rupture. In an autopsy study of 546 cases of nonpenetrating chest trauma, myocardial rupture was found in 65% of cases and myocardial contusion in 24%.1 The incidence of pericardial injury was 11%, while coronary artery or valvular injury was uncommon, occurring in less than 0.5% of cases. Myocardial rupture is the most common cause of cardiac death following blunt chest trauma. Death usually occurs in the field or within the first hour of arriving to the hospital.2 The spectrum of cardiac injury in patients who survive long enough to be hospitalized is very different from the spectrum of cardiac injury seen in autopsy studies. Among patients who survive long enough to be hospitalized, myocardial contusion is the most common cardiac injury and has been reported to occur in 13% to 28% of patients.3-6

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The physician caring for the patient with blunt chest trauma has a number of tools available to diagnose cardiac injury. The most commonly used tests are electrocardiography, serial cardiac enzyme determinations, and echocardiography. Echocardiography has proven to be the most useful test since it provides important information on cardiac structure and function, and can not only diagnose myocardial contusion, but can also evaluate the trauma patient for valvular injury and for the presence of a pericardial effusion. Although early studies found transthoracic echocardiography to be a useful tool in detecting myocardial injury, it is often limited in patients with severe chest injuries because chest wall bandages, chest tubes, and pulmonary injuries limit the acoustic window and affect image quality. TEE is superior to transthoracic echocardiography in providing better imaging of the cardiac structures and overcomes many of the limitations of transthoracic echocardiography in blunt chest trauma. Whether by the transthoracic or transesophageal approach, the diagnosis of myocardial contusion is made echocardiographically by the finding of a regional wall motion abnormality. In addition to a focal area of hypokinesis or akinesis, the involved myocardium is more echogenic and the end-diastolic wall thickness is preserved. The key question faced by the physician caring for the patient with blunt chest trauma is when the TEE should be performed.

In a prospective study conducted at Hahnemann University Hospital, 105 consecutive patients with severe blunt chest trauma underwent transthoracic echocardiography. In 85 of the 105 patients (81%), transthoracic echocardiography provided adequate images to completely assess both right and left ventricular wall motion. Myocardial contusion was detected by transthoracic echocardiography in 22 of the 105 patients (21%). In 20 patients, transthoracic echocardiography was suboptimal due to poor image quality. These 20 patients underwent TEE and myocardial contusion was detected in 9 patients (45%). Combined transthoracic and transesophageal echocardiography detected myocardial contusion in 31 of the 105 patients (30%).

Most commonly, myocardial contusion involves both the right and left ventricles (Figure 2). Myocardial contusion involving both ventricles was seen in 7 of 15 patients (55%). Right ventricular contusion alone was found in 12 of 31 patients (39%) and isolated left ventricular contusion was uncommon and detected in only 2 patients (6%). When the left ventricle was injured, the contusion was limited to a small area of the left ventricular apex and distal anterior septum, and in all cases, the left ventricular systolic function was preserved.

Although there have been case reports of more extensive left ventricular injury following blunt chest trauma, severe left ventricular dysfunction occurring as a consequence of blunt chest trauma is distinctly unusual. In blunt chest trauma, the distal anterior septum and apex are the areas of the left ventricle that come into contact with the lower pole of the sternum and left rib cage. The bulk of the left ventricle is shielded from injury from the anteriorly located right ventricle, and this explains why left ventricular injury is often small and does not lead to significant impairment of left ventricular function.

The anteriorly located right ventricle is more often involved in blunt chest trauma. A small area of injury involving the distal anteroapical right ventricular wall was observed in 72% of patients, while in 28% of patients there was more extensive injury to the right ventricle, leading to sig-

**Figure 1.** Diagram illustrating the location of the heart to the anterior chest wall. During blunt chest trauma, the heart strikes the anterior chest wall, and the right ventricle (RV) suffers the greatest injury due to its anterior location. Ao = aorta, LA = left atrium, LV = left ventricle. Reprinted with permission.29
nificant right ventricular dysfunction.\textsuperscript{15} In several patients right ventricular dilatation with severe global hypokinesis was observed. Since myocardial contusion most often involves the right ventricle, it is important to thoroughly evaluate the right ventricle for injury. The TEE right ventricular inflow and 4-chamber views are best for imaging the right ventricle, though at times modification of these views is necessary. The finding of right ventricular global hypokinesis in a patient with blunt chest trauma is indicative of a right ventricular contusion. In contrast, the finding of a left ventricular wall motion abnormality without right ventricular involvement is unusual in myocardial contusion, and the finding of an inferobasal or anterolateral left ventricular wall motion abnormality with normal right ventricular function is more suggestive of underlying coronary artery disease than myocardial contusion.

Our findings agree with recent studies.\textsuperscript{14,16,17} In a study by Brooks et al, 50 patients with blunt chest trauma underwent both transthoracic and transesophageal echocardiography.\textsuperscript{14} TEE was superior to transthoracic echocardiography in detecting myocardial contusion. A myocardial contusion was detected in 26 patients by TEE and in only 6 patients by transthoracic echocardiography. In these 6 patients, TEE offered no additional diagnostic value. The value of TEE is in diagnosing myocardial injury when the transthoracic echocardiographic study is suboptimal.

TEE can also provide important clinical information on valvular function. Although injury to the semilunar or atrioventricular valves is uncommon, severe valvular regurgitation following blunt chest trauma has been reported.\textsuperscript{24} When a cardiac valve is injured, the aortic valve is more frequently involved, followed by mitral valve and then tricuspid valve injury.\textsuperscript{25} Isolated tricuspid valve injury usually leads to less serious hemodynamic consequences compared to aortic or mitral valve injury.\textsuperscript{26} Aortic or mitral valve injury may present as an asymptomatic heart murmur, or lead to severe heart failure and cardiogenic shock. Any trauma patient with a new heart murmur, unexplained hypotension, or heart failure needs a thorough evaluation for valvular injury (Figure 3).

In our experience, transthoracic echocardiography is limited in evaluating the trauma patient for valvular injury. Although transthoracic echocardiography may detect significant valvular regurgitation, TEE more completely defines the valvular pathology and the severity of valvular regurgitation. McDonald and colleagues reported a case of a patient who had episodes of hypotension following blunt chest trauma.\textsuperscript{27} The transthoracic echocardiogram was unrevealing; however, TEE identified a ruptured papillary muscle and flail anterior mitral valve leaflet with severe mitral regurgitation. Based on the transesophageal echocardiographic findings, the patient underwent emergent cardiac surgery with mitral valve repair and recovered fully.

TEE can also evaluate the patient with blunt chest trauma for pericardial injury. Pericardial injury can lead to hemopericardium with hemodynamic compromise. The clinical findings in cardiac tamponade can be mimicked by right ventricular contusion with severe right ventricular dysfunction. Goldberg and colleagues reported a case of a patient who developed clinical and hemodynamic evidence for cardiac tamponade following severe blunt chest trauma.\textsuperscript{28} The transtho-
Cardiac patients with blunt evidence of cardiac injury were more likely to have a significantly abnormal electrocardiogram (ECG), the sensitivity and specificity of an abnormal ECG relative to the transesophageal echocardiographic findings were poor at 59% and 73%, respectively. In 3 patients with life threatening cardiac injury, one with mitral valve rupture, one with moderate hemopericardium, and one with an intraventricular septal rupture, the ECG was normal. The authors found cardiac enzyme concentrations to be higher among patients with cardiac injury, but no specific amount was found that effectively detected cardiac injury. As with electrocardiography, the sensitivity and specificity of increased cardiac enzymes in diagnosing cardiac injury relative to the transesophageal echocardiographic findings were poor at 64% and 52%, respectively.

An understanding of the location and extent of myocardial injury in blunt chest trauma can explain the poor diagnostic value of electrocardiography and cardiac enzyme determinations in detecting myocardial injury. Although myocardial contusion is common, it often involves only a small area of the left and right ventricles. Small elevations in cardiac enzyme levels may be overshadowed by larger increases in creatinine phosphokinase (CPK) from skeletal muscle injury.

Figure 3. Transesophageal echocardiographic view of a young man with a holosystolic murmur on physical exam following blunt chest trauma from an automobile accident. A. A flail tricuspid valve leaflet (arrow) is seen in the 4-chamber transesophageal echocardiographic view. The right atrium (RA) and right ventricle (RV) are dilated and a RV contusion was present. LA = left atrium, LV = left ventricle. B. Magnified view of the right atrium. Color flow Doppler imaging demonstrates severe tricuspid regurgitation (TR). C. In addition a traumatic atrial septal defect (ASD) was detected. Color flow Doppler imaging demonstrates left to right flow across a large defect in the atrial septum. Reprinted with permission.19
Furthermore, the right ventricle and left ventricular apex, which are the most commonly involved sites in myocardial contusion, are electrically silent on the surface ECG. A certain critical mass of myocardium must be injured to lead to detectable cardiac enzyme levels or significant abnormalities on an ECG.

Clinical findings, electrocardiography, and cardiac enzyme determinations do not reliably predict myocardial injury in patients following blunt chest trauma. The most accurate method of diagnosing cardiac injury is echocardiography. Transthoracic echocardiography is of value if the image quality is adequate; however, if the image quality is suboptimal, then imaging from the transesophageal approach is superior. Patients with the most severe chest wall injuries are the ones who are most likely to have suboptimal transthoracic echocardiographic studies and the ones most likely to have suffered cardiac injury. In our study, the incidence of myocardial contusion in patients with suboptimal transthoracic echocardiographic studies was 45%. Although TEE is the most accurate test to diagnose cardiac injury, the key question is whether it should be used to screen all patients for cardiac injury or reserved for patients with signs or symptoms of cardiac injury.

It was thought that patients with asymptomatic myocardial contusion were at high risk for late cardiac complications. Early case reports documented aneurysm formation, congestive heart failure, life threatening ventricular arrhythmias, and late cardiac rupture. For this reason, patients with blunt chest trauma underwent extensive evaluation to diagnose underlying cardiac injury. It is now recognized that patients with myocardial contusion are at low risk of a late cardiac event and have a favorable prognosis.

In a study from Hahnemann University Hospital, a cardiac event occurred in 10 of 105 patients following severe blunt chest trauma. Echocardiography was highly predictive of a cardiac event. Electrocardiography and cardiac enzyme determinations were not predictive of a cardiac event. Among the 10 patients with a cardiac event, the most common event was an asymptomatic arrhythmia. In only 4 of the 10 patients, representing less than 4% of the study population, did the cardiac event lead to symptoms. Furthermore, among patients with a myocardial contusion, serial echocardiographic evaluation...
demonstrated full recovery in more than one half of patients within 3 months and within one year, all patients with myocardial contusion had normal echocardiographic studies. In 2-year follow-up, no late cardiac events occurred. Although TEE is useful in detecting myocardial contusion, the incidence of symptomatic cardiac events in patients with myocardial contusion is so low, and the long-term prognosis of these patients so good, that routine screening cannot be recommended. Echocardiography is useful in patients who are hemodynamically unstable or who have clinical evidence of underlying cardiac injury. In these patients, if the transthoracic echocardiogram is suboptimal, TEE should be performed to assess the degree of myocardial or valvular injury and to screen for pericardial effusion.

**Transesophageal Echocardiography in Diagnosing Thoracic Aortic Injury**

The incidence of thoracic aortic injury (TAI) following blunt chest trauma has increased considerably over the last several decades due to an increase in the number of high-speed automobile crashes. Between 1936 and 1942, Strassman and colleagues reported an incidence of TAI of less than 1% following blunt chest trauma while Greendyke and Sutorius in the 1960s and 1970s reported an incidence of TAI of 10% to 15%. TAI is the main cause of death following blunt chest trauma and only 20% of victims with TAI survive the first 30 minutes following injury. Recent reports suggest a somewhat better, although still poor, early prognosis with up to 38% of patients with injury to the thoracic aorta surviving the first 30 minutes. This somewhat better outcome results from improvement in the delivery of on-site emergency medical care. Even with these advances, 40% of the initial survivors die within 24 hours and 90% will die by 10 weeks without surgical intervention. Most initial survivors of blunt chest trauma with traumatic aortic injury will die if the aortic injury is not promptly recognized and treated. The physician caring for the patient with blunt chest trauma must have a high index of suspicion for thoracic aortic injury, and when suspected, a rapid and accurate diagnosis must be made.

Often, the echocardiographic features of TAI are confused with those of nontraumatic aortic dissection. The anatomic definitions and echocardiographic features of these two aortic pathologies are different, although some overlap can be seen at times in the elderly. It is important for the cardiologist, anesthesiologist, and trauma surgeon caring for the trauma patient to have a thorough understanding of the pathophysiology and echocardiographic features of TAI and how they differ from nontraumatic aortic dissection.

Nontraumatic aortic dissection occurs from intimal disruption, either from the force of blood flow within the aortic lumen or from within the aortic wall, by hematoma resulting from medial hemorrhage. The intimal surface is then avulsed from the media and adjoining adventitia along the internal elastic membrane. This creates a channel within the aortic wall, a false lumen separated from the true lumen by the avulsed intimal flap. There may be communications between true and false lumens. Since the media and adventitia are intact, the aortic contour is well preserved. Since the false lumen, to a variable extent, behaves like a blind pouch, the blood flow characteristics within the false lumen are quite different from blood flow within the true lumen, with more sluggish flow present within the false lumen. The intimal flap has a characteristic motion that is related to the true and false lumen. The intimal flap moves towards the false lumen in systole and away from the false lumen in diastole. Variable degrees of thrombus formation can be seen in the false lumen and this will affect intimal flap mobility. Little or no mobility of the intimal flap will be seen if the false lumen is partially or completely thrombosed. The transesophageal echocardiographic findings of nontraumatic aortic dissection include a thin mobile intimal flap, a normal aortic contour, and differential flow between the true and false lumens, with more sluggish flow being seen in the false lumen.

In contrast, the pathology in TAI results from vertical or horizontal deceleration, causing torsion and compression of the aorta (Figure 5). The thoracic aorta within the pericardium is anchored at the aortic root and at the ligamentum arteriosum just distal to the origin of left subclavian artery. The torsion and compression forces result in the greatest strain at these anchoring sites. During blunt chest trauma, the aorta is twisted along its long axis and these torsion and compression forces are equally experienced by all layers of the aortic wall both from inside and out. The most common site of injury is around the ligamentum arteriosum just distal to the origin of
When the forces of torsion are minimal, only intimal left become this membrane. Consisting of the aortic wall is limited by the entire circumference of the thoracic aorta. In total, it is limited in the aortic isthmus, the most common site of traumatic aortic injury. Reprinted with permission.57

The left subclavian artery off the distal aortic arch. When the torsion and compression forces are minimal, only intimal hemorrhage occurs. If the torsion forces are greater, then the intima and media become avulsed from the external elastic membrane. This creates a thick intraluminal flap consisting of both the intima and media. In this type of aortic injury, the aortic contour is distorted with the thick intraluminal flap separating the true aortic lumen from a pseudoaneurysm contained by the thin adventitial wall.

With greater torsion and compression forces, the entire aortic wall can be severed. This results in total separation of all 3 layers of the aortic wall and is often referred to as an aortic transection. The aortic transection is complete if it involves the entire circumference of the aorta or partial if it is limited to only part of the aortic circumference. The transesophageal echocardiographic features of a partial thoracic aortic transection include a thick intimal and medial flap, a distorted aortic contour, and a variable sized pseudoaneurysm. In a complete thoracic aortic transection, the true aortic lumen and pseudoaneurysm are contained only by hematoma surrounding the disrupted region. The aortic contour is distorted and the aortic lumen alignment disrupted. In this type of aortic injury, no intimal flap can be identified. Both complete and partial thoracic aortic transections are quite unstable and invariably fatal if not recognized early and surgically corrected.

The diagnosis of TAI is of paramount importance in improving the prognosis of patients with blunt thoracic injuries. Clinical parameters and chest radiography are not adequate in recognizing TAI among survivors of blunt chest trauma.42-44 TEE has been proven of value in evaluating the thoracic aorta in patients suspected of nontraumatic aortic dissection45 and has been used to diagnose TAI in patients following blunt chest trauma.42-44 In experienced hands, TEE can provide high-resolution images and color flow Doppler hemodynamics of the aorta at the bedside. This permits the echocardiographer to identify or exclude TAI with confidence. Furthermore, this obviates the need for transportation of the critically ill patient to the radiology suite, avoids the use of nephrotoxic radiocontrast dye, and also recognizes other comorbidities, such as myocardial contusion, valvular disruption, or pericardial effusion that impact patient care. Several studies have shown the safety and diagnostic value of TEE in diagnosing TAI.42-45 These same studies have also pointed out the pitfalls and limitations of the traditionally used aortogram.

**Figure 5.** Diagrammatic illustration of the stresses that occur on the thoracic aorta during blunt chest trauma. Torsion and compression forces are greatest at the aortic isthmus, the most common site of traumatic aortic injury.
**Transesophageal Echocardiographic Findings in Traumatic Aortic Injury**

Various echocardiographic findings can be seen in TAI. The degree of injury and, therefore, the echocardiographic findings will depend on the extent of the torsion and compression forces experienced by the thoracic aorta, and the depth and circumference of the aortic wall disruption. Since the most common site of injury is in the distal thoracic aortic arch just at or beyond the origin of the left subclavian artery, the physician performing the transesophageal echocardiogram must carefully evaluate this area for injury.

When the aorta is imaged by TEE, the left main stem bronchus creates a blind spot as it courses between the distal ascending thoracic aorta and esophagus. This problem is less important in evaluating the trauma patient since aortic injury most commonly involves the aortic isthmus, an area well visualized from the transesophageal approach. This limitation is also to some extent overcome by using a multiplane transducer. Although uncommon, traumatic aortic injury can occur in the ascending aorta just above the aortic root or in the descending thoracic aorta at the level of the diaphragm (1). Therefore, a thorough assessment of the entire thoracic aorta must be performed in the evaluation for traumatic injury. Since the echocardiographic findings will depend on the extent of the aortic injury, the physician performing the transesophageal echocardiographic study needs to be familiar with the spectrum of aortic injuries and their appearance on the echocardiographic examination.

**A. Injury Limited to the Intimal Surface**

The echocardiographic hallmark of disrupted intima without involvement of the media is a bright linear echo, which is often highly mobile, protruding from the inner aortic wall. Usually it is short in length, and no false lumen is present as is seen in nontraumatic aortic dissection. The aortic contour is well preserved. A small area of intimal avulsion causes this type of aortic injury and the injury to the aortic wall is limited to the internal elastic membrane. In some instances, the intimal disruption results in no flap but exposes the underlying media. The uncovered medial surface may provide a nidus for thrombus formation (Figure 6).

This injury is common and has been described in up to 50% of patients following severe blunt chest trauma.43 These tears do not lead to the for-
formation of a pseudoaneurysm, and the relatively stable media and adventitia provide adequate support to the aortic wall such that late rupture does not occur. Injury limited to the intimal surface will often be missed by aortography. TEE has been shown to be more sensitive in detecting such injury when compared with aortography. These lesions are more stable and often resolve without surgical intervention. It is felt that these patients can be managed conservatively with close clinical follow-up.

B. Injury to the Intima and Media
The echocardiographic hallmark of this type of injury is the presence of an intraluminal flap consisting of the disrupted intima together with the media. The intraluminal flap of TAI is thicker and less mobile than the thinner and more mobile intraluminal flap seen with nontraumatic aortic dissection, which consists of only the intimal surface (Figure 7). Since this type of aortic injury is associated with more extensive injury and deeper disruption of the aortic wall, a pseudoaneurysm forms that distorts the aortic contour. If the injury involves only a small circumference of the aortic wall, the pseudoaneurysm is localized to the site of injury (Figure 8); however, if the injury involves a fairly large circumference of the aorta, a large fusiform pseudoaneurysm contained only by the thin adventitial wall will form.

Figure 7. Transesophageal echocardiogram (A) from a patient with a non-traumatic aortic dissection. The short-axis view of the descending thoracic aorta demonstrates a thin intimal flap which in real time was highly mobile. The aortic contour is preserved. In contrast the transesophageal echocardiogram of a patient with a partial aortic transection (B and C) shows the aortic contour to be distorted. In the short-axis (B) and long-axis (C) views of the descending thoracic aorta the thick intraluminal flap separates the true lumen from the larger pseudoaneurysm above.
Patients with this type of aortic injury are at high risk of subsequent rupture and warrant early surgical repair. At times it can be difficult to differentiate this from a chronic aortic aneurysm. Goarin and colleagues observed that a fusiform aneurysm was more likely to be due to TAI if there was a disparity in the aortic lumen dimension of greater than 1.5 cm between the diameter of the aneurysm and the proximal and distal portions of the aortic lumen.\textsuperscript{43}

**C. Injury to the Intima, Media and Adventitia**

Total separation of all layers of the aortic wall is often referred to as an aortic transection. The aortic transection is complete if it involves the entire circumference of the aorta, or partial if it is limited to only part of the aortic circumference. The transesophageal echocardiographic features of a partial thoracic aortic transection include a thick intimal and medial flap, a distorted aortic contour, and a variable sized pseudoaneurysm. In a complete thoracic aortic transection, the proximal and distal aortic lumen are bound by hematoma surrounding the disrupted region. The transesophageal echocardiographic images will demonstrate a sudden disparity in the aortic lumen diameter and geometry, a large false aneurysm, and turbulent color flow. The aortic contour is distorted and the aortic lumen alignment disrupted. In this type of aortic injury, no intimal flap can be identified; however, if the TEE demonstrates a thick flap, it invariably indicates a partial transection. In addition, the TEE will demonstrate hazy echoes between the transducer and the aorta indicating hematoma. This finding is almost always present in partial or complete transection of the thoracic aorta.

The sensitivity of TEE for diagnosing TAI varies from 81\% to 100\% and the specificity from 88\% to 100\%.\textsuperscript{15,42-44,48} The accuracy of TEE depends on the operator's experience and understanding of the pathology of TAI. The echocardiographer evaluating the thoracic aorta for injury must focus on the aortic morphology, carefully searching for intimal disruption, an intraluminal flap, abnormal aortic contour, or the presence of a pseudoaneurysm. If the aortic morphology appears normal but there is abnormal flow by color flow Doppler or unusual mediastinal echoes indicating hematoma, the physician should be concerned about the possibility of aortic or branch vessel injury. In these cases, ad-
ditional testing with angiography may be indicated. Although TEE is of value in diagnosing traumatic aortic injury, one also has to recognize the limitation of TEE, particularly in diagnosing injury to the major arteries arising from the thoracic aorta.49

In addition to evaluating the aorta for injury in the patient with blunt chest trauma, TEE can aid the physician caring for the trauma patient by identifying associated cardiac injuries.15 These additional findings can favorably impact the management of these critically ill patients. Catoire and colleagues found additional transesophageal echocardiographic findings in 20% of the patients with thoracic aortic injury that led to a change in patient management.50

There is no consensus as yet with regard to the role of TEE in diagnosing traumatic aortic injury. However, it is clear that its negative predictive value is excellent and that it is a useful test to screen the thoracic aorta for injury. There is a significant learning curve for the operator who must be aware of certain pitfalls in imaging the aorta for injury and not misinterpret as TAI other aortic pathology (frequently seen in elderly patients) or normal aortic structures. The transesophageal echocardiographic features of a partial or complete traumatic aortic transection are not subtle and can be easily diagnosed. However, more skill and experience is needed to diagnose small aortic disruptions or injury limited to the aortic intima. Furthermore, experience is needed to distinguish TAI from other forms of aortic pathology. Difficulty may arise in differentiating a localized intimal tear from focal atherosclerotic debris. Atherosclerotic aortic debris tends to occur in older patients at risk for atherosclerosis, is diffuse, and is associated with calcifications of the intimal surface with overlying thrombus.51 A localized traumatic intimal tear will lack the intimal calcifications present in atherosclerotic aortic debris, although overlying thrombus has been described adherent to a traumatic intimal tear. Care should also be taken not to misinterpret the subclavian vein, azygous vein, transverse sinus, or reverberation artifact in the ascending aorta as TAI (Figure 9).

If TEE is equivocal or if a mediastinal hematoma is present indicating vascular injury, the patient should be referred for angiography. If, on the other hand, the TEE is of good quality and the echocardiographic findings are negative, the physician caring for the trauma patient should feel confident in excluding the diagnosis of TAI.

Figure 9. Transesophageal echocardiographic examples of artifact that can mimic traumatic aortic injury. In each case, the arrow points to reverberation artifact from the aortic wall that can mimic an intraluminal flap and lead to a mistaken diagnosis of traumatic aortic injury. Operator skill and experience is mandatory when evaluating the aorta in the trauma patient. Reprinted with permission.19
Transesophageal Echocardiography in Diagnosing Mediastinal Injury

As with injuries to the heart and aorta, injuries to the great veins, aortic branch vessels, and aerodigestive tract can occur after blunt chest trauma. In a study of 515 patients with blunt chest trauma, Shorr and colleagues\(^1\) reported the incidence of nonaortic great vessel injury to be 2%, occurring in 9 of 515 patients. Of these 9 injuries, 3 were injuries to the innominate artery, 2 were subclavian avulsions, 1 was an azygous vein laceration, and 1 was a combined pulmonary artery and pulmonary vein avulsion.

In our experience, TEE is limited in evaluating the great veins, aortic branch vessels, and the aerodigestive tract for injury. While venous injuries usually do not require operative therapy, an aortic branch vessel injury, although uncommon is potentially devastating. Physicians must recognize the limitations of TEE in diagnosing aortic branch vessel injury following blunt chest trauma. For example, Prêtre and colleagues\(^2\) reported a case of a patient with an enlarged mediastinum following blunt chest trauma. TEE was unable to diagnose an innominate artery avulsion found on angiography.

Smith and colleagues\(^3\) reviewed their series of 81 patients with great vessel injury following blunt chest trauma and found that 15 patients (19%) had aortic branch vessel injury. Twelve patients, fully 15% who had aortic branch vessel injury, had no evidence of injury to the thoracic aorta. The aortic branch vessel injuries were substantial and included 7 left subclavian, 5 brachiocephalic, 4 left common carotid, 3 right subclavian, and 2 internal thoracic artery injuries. Other studies have reported a lower incidence of aortic branch vessel injury. In a study of 172 suspected thoracic aortic injuries following blunt chest trauma, only 3 patients (2%) were found to have injuries to the aortic branch vessels.\(^5\) All the injuries involved the left subclavian artery and all were associated with arm blood pressure differences, brachial plexopathy, or both.

If TEE is the sole modality used to diagnose mediastinal injury, aortic branch vessel injury will often be missed. Although TEE may offer a unique real time view of the aorta, physicians and surgeons must be alert to the possibility of associated mediastinal arterial and venous injury in the absence of aortic injury and consider contrast arteriography that visualizes not only the aorta but also its mediastinal branches.

TEE may provide clues for aortic branch vessel injury. When a mediastinal hematoma is detected by TEE (Figure 10) the physician caring for the trauma patient must pursue further testing.

**Figure 10.** Transesophageal echocardiogram of a mediastinal hematoma. A large hematoma is seen separating the aorta (Ao) from the visceral pleura below. The magnified view in the top right corner clearly demonstrates that the intimal surface of the aorta is intact. Reprinted with permission.\(^19\)
with aortography. Although a nonspecific finding, the presence of a mediastinal hematoma may indicate injury to the aorta, its branch vessel, or injury to the great veins. LeBrett and colleagues described 3 transesophageal echocardiographic criteria to diagnose traumatic mediastinal hematoma: (1) an increased distance between the echocardiographic probe and the aortic wall, (2) a double contour of the aortic wall, and (3) the visualization of the ultrasound signal between the aortic wall and visceral pleura.

Systemic gas embolism has been diagnosed using TEE. Prior to TEE, this condition was rarely diagnosed premortem. Saada and colleagues reported 3 cases of severe blunt thoracic trauma with pulmonary contusion where hemodynamic instability prompted the use of TEE. The examination revealed air bubbles in the left atrium during the inspiratory ventilation cycle that were absent during exhalation. This finding prompted a change in clinical management, with either institution of high frequency jet ventilation or conventional ventilation with decreased tidal volume and positive end-expiratory pressure. Both maneuvers reduced the systemic air emboli and improved the hemodynamic status of the patients.

Because blunt esophageal injury is extremely rare, TEE can safely be performed in adults following blunt chest trauma without unduly risking esophageal injury. In children with blunt thoracic trauma, TEE can be used but caution must be exercised. Greene and colleagues reported on patients undergoing elective cardiac surgery and indicated that continuous transesophageal echocardiographic evaluation resulted in esophageal mucosal damage in 80% of pediatric patients weighing less than 9 kilograms and in 48% of those children weighing more than 9 kilograms. While the duration of the transesophageal echocardiographic examination in that study was long, exceeding 260 minutes and while no long term feeding or swallowing sequellae were noted, caution should always be exercised when selecting pediatric patients for transesophageal echocardiographic examination. Both the physical contact of the probe with the mucosa, as well as any heat dissipated by the probe, can pose potential problems for the esophagus. Physicians performing TEE should keep their evaluations as short as possible while striving to obtain optimal images of the mediastinal structures. In our experience, the average time of a transesophageal echocardiographic examination in the hands of an experienced operator for adult trauma patients is less than 15 minutes.

In conclusion, TEE represents an excellent method to visualize the aorta in trauma patients. Care must be exercised in drawing conclusions about nonaortic mediastinal vessels, especially mediastinal branch vessels of the thoracic aorta. There is a small but definable incidence of injury to these vessels, even in the absence of aortic injury, and TEE will often miss the diagnosis of aortic branch vessel injury. Judicious use of contrast mediastinal arteriography must include visualization of the aortic branches. TEE can safely be performed in adult trauma patients but care must be used in the pediatric group since prolonged transesophageal echocardiographic examinations can result in esophageal mucosal damage. Further, injuries such tracheopulmonary lacerations and contusions can cause systemic air embolism, which can uniquely be seen in real time by TEE. Continuous transesophageal echocardiographic examination during ventilator adjustments can be used as a guide to optimize ventilation while minimizing systemic air embolism.

**Conclusions**

TEE is an important tool for the physician caring for the patient following blunt chest trauma because it provides direct visualization of cardiac structure and function, and can rapidly and accurately diagnose cardiac and aortic injury at the bedside. TEE offers the advantage of providing superior imaging of the heart when the transthoracic approach is limited and can assess traumatic aortic injury as accurately as, and more rapidly than, aortography. Skill in interpreting the echocardiographic finding is essential to avoid misdiagnosis and maintain accuracy. By understanding the advantages and disadvantages of TEE in diagnosing cardiac and aortic injury, the physician caring for the trauma patient will be able to utilize echocardiography in the trauma patient more effectively. TEE can lead to earlier diagnosis of cardiac and aortic injury and direct appropriate therapy, thereby improving survival in patients who suffer traumatic injury to the heart or great vessels.
References


