Quantification of Traumatic Hemomediastinum Using Transesophageal Echocardiography*

Impact on Patient Management

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Study objectives: To determine whether the quantitative evaluation of hemomediastinum using transesophageal echocardiography (TEE) is predictive of the presence of a traumatic disruption of the thoracic aorta (TDA) or its branches in patients who have sustained severe blunt chest trauma.

Design: Retrospective study.

Setting: ICU of a tertiary referral teaching hospital.

Patients: Forty-one patients sustaining severe blunt chest trauma (32 men, nine women; mean age, 43±16 years; mean Injury Severity Score, 39±22) who underwent a TEE study were divided into two groups, patients with (group TDA+, n=15) or without (group TDA−, n=26) major vascular injury diagnosed using an alternative method such as aortography, surgery, or necropsy. The control group included 41 age- and sex-matched patients with an unremarkable TEE study performed to rule out an intracardiac source of emboli.

Interventions: The presence of hemomediastinum was quantitatively assessed by measuring the distances between the esophageal scope and anteromedial aortic wall (distance 1), and between the posterolateral aortic wall and left visceral pleura (distance 2) at the level of the aortic isthmus. An observer who was unaware of both medical history and final diagnosis measured the distances.

Measurements and results: In group TDA+, TEE demonstrated aortic injuries in 13 patients, revealed an isolated hemomediastinum in one patient (ruptured intercostal arteries), and was unremarkable in the remaining patient, who sustained a disrupted right subclavian artery. No associated major vessel injuries were diagnosed in the group TDA− (normal aortograms). When compared to the control group, mean distances were greater in patients with chest trauma (distance 1=5.5±4.4 mm vs 2.7±0.8 mm, p=0.001; distance 2=3.8±5.0 mm vs 1.2±0.3 mm, p=0.02). The corresponding distances were even greater in group TDA+ when compared with group TDA− (distance 1=8.6±5.9 mm vs 3.7±1.5 mm, and distance 2=7.1±7.0 mm vs 2.0±1.7; for both differences, p<0.01). A threshold value of 5.5 mm for distance 1 or 6.0 mm for distance 2 had a sensitivity of 80%, a specificity of 92%, a positive and negative predictive value of 86% and 89%, respectively, for the diagnosis of underlying major vascular injury.

Conclusions: TEE allows quantitative assessment of traumatic hemomediastinum. The presence of a large hemomediastinum requires further evaluation by aortography, even if the thoracic aorta appears normal during the TEE examination, in order to rule out an underlying major vascular injury which may be outside the field of view of the echocardiographer. (CHEST 1998; 113:1475-80)

Key words: aortic disruption; hemomediastinum; transesophageal echocardiography

Abbreviations: CI=confidence interval; ISS=Injury Severity Score; ROC=receiver operating characteristic; TDA=traumatic disruption of the thoracic aorta or its branches; TEE=transesophageal echocardiography

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Traumatic disruption of the thoracic aorta (TDA) or its branches is a life-threatening injury caused by severe blunt chest trauma secondary to violent deceleration. Because of its diagnostic accuracy, versatility, and safety, transesophageal echocardiography (TEE) has recently been proposed as a first-line imaging technique for the evaluation of patients with suspected TDA.1-3 Although TDA is predominantly located in the region corresponding to the aortic isthmus, lesions involving the ascending aorta...
Objective criteria went quantification of described were been of this population. Trauma groups, two hemomediastinum measured branches, diagnostic cerebral ischemic or aortography in an examination. A recent Le Bret et al have demonstrated the value of TEE in diagnosis of traumatic hemomediastinum. Although a hemomediastinum has been shown to occur frequently in association with TDA, patients sustaining severe blunt chest trauma may also have mediastinal hematomas secondary to other vascular and nonvascular injuries (eg, disruption of small mediastinal vessels, sternal or dorsal vertebrae fractures).

In the present study, we sought to determine whether quantification of traumatic hemomediastinum using TEE allows prediction of the presence of an associated traumatic injury to the thoracic aorta or its branches, which in turn, would require diagnostic aortography in the presence of a negative TEE examination.

Materials and Methods

Population Study

Over a 24-month period, patients sustaining severe blunt chest trauma requiring mechanical ventilation were retrospectively studied when they fulfilled the following inclusion criteria: (1) victims of a violent deceleration collision or fall from a height >5 m; (2) TEE performed in the first 24 h after admission; and (3) diagnostic confirmation of the TEE findings by aortography, surgery, or necropsy. Age- and sex-matched patients who underwent an unremarkable TEE examination following a transient cerebral ischemic event during the same period were also studied and constituted the control group.

Patients sustaining severe blunt chest trauma were divided into two groups, according to the presence (group TDA+) or absence (group TDA−) of traumatic injury to the thoracic aorta or its branches. In each patient, the injury severity score (ISS) was calculated and thoracic and extrathoracic lesions were recorded. The use of TEE in the diagnosis of TDA has previously been described in some of the subjects who constitute the patient population of this study. In none of these patients was the hemomediastinum measured to detect underlying traumatic injuries to major vessels.

Transeosophageal Echocardiography

Transeosophageal studies were performed using a 5-MHz monoplane or multiplane probe connected to an ultrasound system (SONOS 1500; Hewlett-Packard; Andover, Mass). Patients with blunt chest trauma were studied in the supine position. When present, the nasogastric tube was removed to enable improved contact between the scope and the esophageal mucosa. Conventional two-dimensional and Doppler TEE study were performed, with particular attention directed towards the examination of the thoracic aorta. The ascending aorta was examined 25 to 30 cm from the incisors. After performing a counterclockwise rotation of the TEE probe, the descending thoracic aorta was carefully examined in the transverse view for detailed visualization of the region corresponding to the isthmus (distal to the origin of the left subclavian artery). The aortic arch was examined in the conventional transverse plane and the esophageal probe was withdrawn. All TEE studies were recorded on videotape for off-line analysis.

Video tapes of TEE studies performed in patients with blunt chest trauma were subsequently reviewed by an experienced observer who was unaware of the final diagnostic confirmation. The echocardiographic diagnosis of TDA was based on the presence of (1) a mobile medial flap or disrupted wall appendage within the thoracic aorta in conjunction with a false aneurysm formation; and (2) similar blood flow velocities on both sides of the intraluminal linear image associated with blood flow turbulence in the surroundings of the disrupted aortic wall.

In each patient (TDA+, TDA−, and control groups), the distances between the esophageal scope and the anteromedial aortic wall (distance 1) and between the posterosilateral aortic wall and the left visceral pleura (distance 2) were measured using electronic calipers (Fig 1). Both distances were measured in the region of the aortic isthmus, which is located between the origin of the left subclavian artery and the first intercostal arteries. The aortic isthmus was echocardiographically identified as the region where the descending thoracic aorta first appears round-shaped in the transverse view (25 to 28 cm from the incisors). Measurements were performed at end-diastole (peak R wave) using the leading edge technique. Initially, the experienced reader selected...
a representative two-dimensional image of the aortic isthmus and measured both distances. Subsequently, another observer trained in TEE, but without experience in the echocardiographic evaluation of patients with chest trauma, used the identical still-frames to independently measure distances 1 and 2. This last observer again measured both distances 2 weeks later, with no access to his initial data.

**Statistical Analysis**

The frequency of thoracic and extrathoracic traumatic injuries in the TDA+ and TDA− groups was compared using Fisher's exact test.

The reproducibility of measurements (intraobserver variability) was calculated for each distance as the percentage of the difference between the two values obtained after a 2-week interval, divided by the mean of both measurements. Similarly, interobserver variability was calculated as the percentage of the difference between the mean of both values obtained in each patient by the less experienced observer and the corresponding value provided by the experienced observer, divided by the mean.

Results are shown as mean±SD. Distance 1 and 2 measurements in both groups were compared using the nonparametric Mann-Whitney rank sum test. In all cases, p values ≤0.05 were considered statistically significant.

To determine the threshold value of both measured distances that provides the highest diagnostic accuracy for the identification of underlying TDA, receiver operating characteristic (ROC) curves were built as follows. Initially, ROC curves that plot the true-positive fraction on the vertical axis (sensitivity) against the false-positive fraction on the horizontal axis (1-specificity) as the value of the distance changes, were built separately for distance 1 and distance 2. This allowed visual determination of the respective threshold value for each distance associated with the highest sensitivity and specificity. Compared with distance 2, the threshold value of distance 1 provided the highest diagnostic accuracy. Subsequently, to create the ROC plot for the combination of both distances, this latter threshold value was maintained constant while the value of distance 2 was varied in increments of 3 mm.

**RESULTS**

Forty-one patients who sustained severe blunt chest trauma were included in the study (32 men, nine women; mean age, 43±16 years; range, 18 to 75 years). Their mean ISS was 39±22. Group TDA+ included 15 patients and group TDA−, 26 patients. The mean age was similar between groups (40±17 years vs 45±16 years; p=0.4). Traumatic injuries were more severe in group TDA+, as reflected by a higher mean ISS when compared with group TDA− (60±20 vs 27±12; p=0.001). Specifically, associated head trauma and diaphragmatic rupture were more frequently observed in patients with TDA (10/15 vs 7/26 and 4/15 vs 0/26, respectively; p≤0.02), whereas the frequency of other traumatic injuries was similar in both patient groups. The control group included 41 patients with a normal TEE study (32 men, nine women; mean age, 45±16 years; range, 19 to 74 years).

In 13 of the 15 patients in group TDA+, TEE demonstrated the presence of a subadventitial aortic rupture located in the region of the isthmus in conjunction with a hemomediastinum (Fig 2). In all cases, the traumatic disruption of the aortic wall was confirmed by aortography and/or during surgery (n=11), or by necropsy (n=2). In the remaining two patients, TEE showed apparent integrity of the thoracic aorta. One patient had an unremarkable TEE study while aortography disclosed a traumatic disruption of the proximal right subclavian artery, which was successfully repaired surgically. In the other patient, TEE examination revealed only a large hemomediastinum. During surgery, this hemomediastinum was related to an avulsion of several intercostal arteries. No cardiac compression secondary to the presence of posterior mediastinal hematomas was encountered. In patients in group TDA−, no apparent traumatic aortic wall disruption was diagnosed during TEE examination. Aortographic findings were interpreted as normal in all cases.

When compared with the value in the control group, the mean distance 1 was greater in patients with chest trauma (5.5±4.4 mm vs 2.7±0.8 mm; p=0.001), irrespective of the presence or absence of a traumatic arterial disruption (Table 1). This distance was significantly higher in group TDA+ than in group TDA− (Table 1). When the distance

**FIGURE 2.** Transesophageal echocardiographic transverse view of the aortic isthmus in a patient with a traumatic aortic disruption secondary to a severe blunt chest trauma. Note the presence of a thick intraluminal medial flap (single-headed arrow) in conjunction with a hemomediastinum that shifts the descending thoracic aorta posteriorly (double-headed arrow) from the esophageal scope. As a result, the distance between the esophageal probe and the anteromedial aortic wall is increased (>4 mm) by the presence of blood around the descending thoracic aorta.
between the esophageal scope and the anteromedial aortic wall was greater than 6.7 mm, a traumatic injury involving the thoracic aorta or its branches was consistently present. Similarly, distance 2 was greater in patients who had sustained severe chest trauma than in the control group (3.8±5.0 mm vs 1.2±0.3 mm; p=0.02). This distance was larger in the presence of a major vascular injury (Table 1). Beyond a threshold value of 7.0 mm, a traumatic injury of the thoracic aorta or its branches was consistently present.

In group TDA+, distance 1 was less than 6.7 mm in six patients and distance 2 was less than 7.0 mm in nine patients. In addition, both distances were below the corresponding values in four patients (29%) with traumatic vascular injuries. The threshold values of 5.5 mm for distance 1 and 6.6 mm for distance 2 were identified on the ROC plots as the values providing the highest diagnostic accuracy (Fig. 3). Thus, the criterion “presence of a distance 1 ≥5.5 mm or a distance 2 ≥6.6 mm” had a sensitivity of 80% (confidence interval [CI], 60-100%) and a specificity of 92% (CI, 81-100%) for the diagnosis of underlying injuries to the thoracic aorta and its branches. The positive and negative predictive values were 86% (CI, 64-100%) and 89% (CI, 78-100%), respectively.

The intraobserver variability was 9.9% for measurement of distance 1 and 11% for distance 2. Interobserver variability for distances 1 and 2 was 7.9% and 14.2%, respectively.

**DISCUSSION**

In the present study, we have demonstrated that quantification of the severity of a hemomediastinum using TEE is reproducible and allows prediction of the presence of an associated traumatic injury to the thoracic aorta or its branches. In addition, we hereby propose measurements of hemomediastinum severity to help identify patients who should undergo further evaluation by aortography in the presence of a negative TEE examination.

**TEE Diagnosis of Hemomediastinum**

The TEE signs associated with traumatic hemomediastinum have been initially described by Le Bret et al. who compared the TEE findings for 22 patients who sustained severe chest trauma with findings obtained from a thoracic CT scan and/or surgery. The presence of an increased distance between the probe and the anteromedial aortic wall (corresponding to the distance 1 in the current study) was found to be the most consistent because all patients with proven hemomediastinum had a posterior shift of the descending thoracic aorta ≥4 mm, whereas in 20 brain-dead patients used as controls, this distance never exceeded 3 mm.

In the current study, an increased distance between the probe and the anteromedial aortic wall was present in 12 patients in group TDA+ (80%) and 10 patients in group TDA− (38%). In keeping with the results reported by Le Bret et al., only one patient in our control group exhibited a distance 1 greater than 4 mm. Although the presence of a hemomediastinum was noticed more frequently when a TDA was simultaneously present (12/15 vs 10/26; p=0.02), this represents a common TEE finding in patients sustaining severe chest trauma and therefore cannot accurately predict the presence of an underlying traumatic lesion of the thoracic aorta or its branches. This is presumably explained by the various etiologies of mediastinal hematoma after a chest injury secondary to an abrupt collision. In the present series, the frequency of first
rib or multiple rib fractures and sternal or thoracic vertebral fractures was similar whether or not an echocardiographically diagnosed hemomediastinum was present (p≥0.6). In these patients, tears of small arteries and veins surrounding the thoracic aorta or located in the upper mediastinum may have also led to the formation of a mediastinal hematoma.9

**TEE Quantification of Traumatic Hemomediastinum**

We have demonstrated the reproducibility and relatively low interobserver variability of both measurements used to quantify mediastinal hematoma. Despite the technical limitation of depth resolution in the near field, the measurement of distance 1, which is of great value for the TEE diagnosis of hemomediastinum, does not appear to be experience-dependent. However, to avoid false-positive diagnoses of mediastinal hematoma, measurement of the distance between the probe and the anteromedial aortic wall must be performed strictly at the level of the aortic isthmus, which is an easily identifiable anatomical landmark. Because the descending thoracic aorta anatomically moves away from the esophagus as it approaches the diaphragm, the threshold value proposed for distance 1 is not valid if measurements are performed distal to the aortic isthmus. Rarely, traumatic lesions of the distal descending thoracic aorta are not associated with a hemomediastinum at the level of the aortic isthmus.

Due to the high frequency of hemomediastinum observed in our study population (54%), mean distances 1 and 2 were significantly higher in patients with chest trauma than in the control group. Since the abundance of peri-aortic tissue may be age- and sex-dependent and affect both distances, patients with unremarkable TEE studies were matched to the victims of severe chest trauma. Interestingly, both distances were even greater when a traumatic arterial injury was present. Since these distances reflect the amount of blood collected around the descending thoracic aorta, the size of the hemomediastinum was greater when it was secondary to a major vessel injury when compared to mediastinal hematoma of other traumatic origin. All patients with measurements above the threshold values of 6.7 mm (distance 1) and 7.0 mm (distance 2) had an associated TDA. Although specific, these threshold values are not sensitive enough in a substantial proportion of patients with a TDA, each distance was below the threshold values. In contrast, the presence of a distance 1 ≥5.5 mm or a distance 2 ≥6.6 mm provides a relatively high sensitivity and specificity for the diagnosis of an underlying major vascular injury. Accordingly, when the TEE examination discloses a hemomediastinum in the absence of an apparent TDA, but its size exceeds the above-mentioned threshold values, we recommend performing aortography. This would allow the diagnosis of vascular injuries that are not accessible to TEE examination, eg, avulsion of intercostal arteries, which was observed in one of our patients who presented with an apparently isolated large hemomediastinum.

Of note, only three patients suffered from major arterial lesions and had both distances below the proposed threshold values. Two of these patients had typical TEE findings of TDA confirmed during surgery. The remaining patient exhibited no signs of hemomediastinum and the TEE examination was interpreted as normal, whereas aortography clearly depicted a laceration of the proximal right subclavian artery. Surgical exploration revealed a ruptured false aneurysm with a hematoma collected in the apical extrapleural space of the right lung, which accounted for the absence of hemomediastinum. Similar findings have been previously reported in CT scan studies, in which disruptions of proximal brachial arteries were not associated with mediastinal hematomas.14

**Limitations**

The echocardiographic measurements proposed in this study to quantitate traumatic hemomediastinum were not validated by using an alternative noninvasive imaging modality such as CT scanning, usually considered the gold standard for the examination of the mediastinum.14 In addition, this study was retrospectively performed in patients with severe blunt chest trauma who fulfilled specific inclusion criteria, which may have introduced bias in the results. However, to the best of our knowledge, this study is the first to propose the quantification of hemomediastinum with TEE as a guide for management of patients with suspected TDA. In addition, both proposed distance measurements have been shown to be reproducible and have low interobserver variability. Finally, the use of a control group including age- and sex-matched patients with unremarkable TEE findings allowed us to determine normal comparison values for each distance studied.

**Conclusions**

Quantification of traumatic hemomediastinum using TEE is reproducible and allows prediction of the presence of an associated injury to the descending thoracic aorta or its branches. When the distance between the esophageal scope and the anteromedial aortic wall...
and the left visceral pleura, is increased beyond specific threshold values, further evaluation by aortography is indicated. This invasive procedure remains the reference technique for the diagnosis of traumatic disruptions of aortic branches. The proposed approach promises to facilitate the management of patients who have sustained severe blunt chest trauma and to reduce false-negative results of TEE due to vascular injury located outside the echocardiographer’s field of view.

REFERENCES