CASE 2—2014
Aortic Dissection: Real or Artifact?

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A CUTE ASCENDING AORTIC DISSECTION is a serious condition with significant mortality requiring prompt diagnosis and surgical treatment as mortality rates increase hourly without intervention.¹ ² There are a number of modalities currently used to diagnose aortic dissection, including computed tomography (CT), magnetic resonance imaging (MRI), and transesophageal echocardiography (TEE), each with different strengths and weaknesses in regard to speed, accuracy, and ease of performance. There exists a balance between rapid diagnosis with comprehensive information regarding anatomic detail, vascular branch involvement, false lumen identification, and speed with which the diagnosis can be made to expedite potential surgical treatment. The optimal diagnostic mode for identifying ascending aortic dissection remains controversial. Additionally, the various methods of imaging used to evaluate for aortic dissection all carry potential disadvantages of artifact within the image, complicating the diagnostic process and at times leading to false-positive diagnoses. Managing this balance represents some of the difficulties in identification and treatment of these patients. The authors present a patient who was anesthetized for repair of a suspected ascending aortic dissection based on CT findings, yet subsequent TEE revealed normal anatomy.

CASE PRESENTATION

A 47-year-old African American male (170 cm/79 kg) was transferred to the authors’ institution for surgical management of an acute type-A aortic dissection noted on CT scan after presenting to an outside hospital with initial symptoms of shortness of breath, chest pain, and nausea. He had a past medical history of hypertension, type II diabetes, and gastroesophageal reflux disease. His past surgical history was significant for a right rotator cuff repair. Daily home medications included oral lisinopril-hydrochlorothiazide (20/25 mg daily), metformin (500 mg twice daily), and rabeprazole (20 mg daily). He had undergone esophagogastroduodenoscopy 3 days prior to the date of presentation following complaints of epigastric/abdominal pain as well as difficulty swallowing solid foods and was diagnosed at that time with a gastric ulcer for which he was started on the rabeprazole. He awoke on the morning of presentation with shortness of breath, chest pain radiating to his right upper quadrant, and hot flashes, and he had an episode of nausea and vomiting. At work, he had another episode of nausea and vomiting and called an ambulance to transport him to the nearest hospital. En route in the ambulance, he continued to complain of chest pain and was given sublingual nitroglycerin, which failed to relieve the pain. He was not treated with aspirin at that time given a concern for the recently diagnosed gastric ulcer. On admission to the outside hospital emergency room, his vital signs were stable. Electrocardiogram revealed normal sinus rhythm without evidence of ischemia. He subsequently underwent a CT scan, which demonstrated a type-A aortic dissection 2.0 cm distal to the aortic valve extending approximately 15 mm (Fig 1). He continued to be managed with intravenous morphine for pain and intravenous boluses of labetalol to maintain a systolic blood pressure below 125 mmHg and was transferred directly to the operating room for surgical repair of the dissection.

Preoperative vital signs demonstrated a blood pressure of 156/89 mmHg, heart rate 65 beats-per-minute, temperature 35.8°C, respiratory rate of 17 breaths per minute, and oxygen saturation of 99% on 2.0 L nasal cannula. Following left radial arterial catheter insertion, uneventful anesthetic induction was performed with 500 µg of fentanyl, 8 mg of midazolam, 50 mg of propofol, and 10 mg of vecuronium. He was intubated uneventfully with an 8.0 endotracheal tube and placed on inhaled isoflurane for maintenance. A TEE probe was inserted easily without hemodynamic changes. Upon evaluation of the ascending aorta, a questionable artifact was noted, but no obvious dissection was seen (Fig 2). A curvilinear object was noted in the ascending aorta that initially appeared to be a dissection flap located in the same position as the prior CT evidence of dissection. However, on further evaluation the suspected dissection line extended outside the anatomic boundary of the aortic wall with no difference in color-flow Doppler on either side. No other evidence of dissection, such as aortic insufficiency or pericardial effusion was noted (Fig 3). The midesophageal aortic...
valve long-axis view demonstrated normal anatomy (Fig 4). Following consultation with the cardiac surgeon and a cardiologist as well as a re-review of the outside CT scan, it was determined that the CT and TEE findings likely were artifacts, and the decision was made to cancel the case at that point and repeat the CT scan. No central venous or pulmonary artery catheter had been placed at this time, and no incision ever was made. Per radiology recommendations, the patient underwent followup CT angiogram, which confirmed the lack of a dissection. He was observed overnight in the intensive care unit. Cardiac enzymes were evaluated and remained negative for signs of ischemia. He was transferred to the medical floor for further management of continued right upper quadrant pain and was discharged home in stable condition on postoperative day 3.

**DISCUSSION**

Acute type-A aortic dissection is a life-threatening condition requiring urgent detection given the significant morbidity and mortality associated with it. The true incidence of acute aortic dissection is difficult to determine, but population studies estimate it to be around 0.5 to 4.0 cases per 100,000 people per year. This number has been increasing over the years, possibly secondary to improved diagnosis with advances in imaging technology. Medical management of type-A aortic dissection is associated with significant mortality: 20% at 24 hours after presentation, 30% at 48 hours, 40% at 1 week, and 50% at 1 month. Even with surgical treatment, mortality remains high for type-A dissection, with rates ranging from 10% after 24 hours to 20% after one month. Given the substantial mortality of this disease, it is considered a true surgical emergency, and rapid diagnosis is a necessity. This is possible with several different modes of imaging.

The overall process of diagnosing type-A aortic dissection involves a series of decisions regarding the optimal imaging modality for rapid diagnosis with the highest accuracy possible. There exists a balance between precise diagnosis and excessive delays in diagnosis that prolong initiation of surgical management. A number of variables are used to determine the optimal diagnostic modality, including probability of disease, the risks
and benefits of each procedure, the accuracy of each test, and the delays that are necessary to perform a specific diagnostic examination. In the past, aortic dissection was evaluated with aortography; however, this modality largely has been replaced by noninvasive imaging techniques. In current practice, CT, MRI, and TEE all can be used with high sensitivity to diagnose aortic dissection but each has varying strengths and weaknesses (Table 1). There have been a number of investigations aimed at determining the best diagnostic technique for accurately identifying patients with ascending aortic dissection with comparable results: CT, MRI, and TEE yield similarly acceptable sensitivities for diagnosis of ascending aortic dissection, with TEE having a slightly lower specificity. Transthoracic echocardiography has been used to provide bedside information in the setting of dissection and can be performed quickly without requiring transport of the patient; however, it does not have sufficient sensitivity or specificity to be used as a single method for diagnosis of aortic dissection (sensitivity only 59%).

According to the International Registry of Acute Aortic Dissection, CT scanning is the most common diagnostic modality initially used for detection of aortic dissection. In a pooled analysis of helical CT, it has a high sensitivity and specificity (100% and 98%, respectively), with the lowest negative likelihood ratio of the 3 imaging modalities, suggesting its usefulness at ruling out the presence of type-A aortic dissection. Furthermore, CT is fast (average time 5 to 15 minutes in 1 study) and easily accessible, and helical CT provides suitable delineation of aortic anatomy. Limitations of CT include the requirement for radiation exposure and contrast administration. Unlike the other imaging modalities, CT does not provide information regarding the presence of aortic insufficiency. Conventional CT has not been shown to reliably provide information on the location of the entry site of dissection; however, newer helical CT appears to be better at this task. In addition, there are a number of cases of CT producing artifacts that resemble aortic dissections, as the one in this case. Reviews of false-positives on CT have shown that technical factors such as beam hardening and streak, ring, band, and bloom artifacts all can result in poor image quality but are easier to identify by technologists as artifact. Streak artifacts may be projected within the boundaries of the aorta, which can lead to misinterpretation as a dissection flap. These typically appear as parallel or radiating lines, not necessarily restricted to the aortic lumen and usually appear in only 1 or 2 tomographic levels. Motion artifact is another potential cause of CT artifact and can be difficult to distinguish from true pathology as it usually is not associated with other problems in image quality. Subtle curvilinear shadows may be projected inside the lumen of the ascending aorta due to aortic distention from ejected stroke volume and systolic and diastolic movements of the aorta. The result of these shadows from aortic dissection can be a motion artifact that appears as a smooth crescent-shaped intimal flap, which may have been the cause of the artifact seen in the CT image of this patient.

MRI demonstrates high sensitivity and specificity in numerous studies pooled via meta-analysis with both sensitivity and specificity of 98%. In addition, it has the highest positive likelihood ratio of the 3 diagnostic modalities, suggesting it may be superior in discriminative power for confirming type-A aortic dissection. MRI is highly reliable at identifying the dissection entry point as well as providing superior anatomic detail of branch vessel involvement. MRI, although not superior

Table 1. Comparison of Advantages and Disadvantages of CT, MRI, and TEE in the Diagnosis of Type-A Aortic Dissection

<table>
<thead>
<tr>
<th>Imaging Modality</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>CT</td>
<td>- Sensitivity 100% (helical CT)</td>
<td>- Requires use of contrast/ radiation</td>
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<tr>
<td></td>
<td>- Specificity 98% (helical CT)</td>
<td>- Conventional CT unable to reliably demonstrate dissection initiation point</td>
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<td></td>
<td>- Lowest negative likelihood ratio</td>
<td>- Unable to evaluate for AI</td>
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<td></td>
<td>- Fast (5-15 min)</td>
<td>- Potential artifacts</td>
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<tr>
<td></td>
<td>- Accessible</td>
<td>- Motion</td>
</tr>
<tr>
<td></td>
<td>- Able to identify pericardial and pleural effusions</td>
<td>- Technical artifacts</td>
</tr>
<tr>
<td>MRI</td>
<td>- Sensitivity 98%</td>
<td>- Time consuming (23-39 min)</td>
</tr>
<tr>
<td></td>
<td>- Specificity 98%</td>
<td>- Lack of availability in all medical centers</td>
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<tr>
<td></td>
<td>- Highest positive likelihood ratio</td>
<td>- Incompatible with metal implants</td>
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<td></td>
<td>- High anatomic detail of branch vessel involvement including coronary arteries</td>
<td>- Monitoring difficulties</td>
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<tr>
<td></td>
<td>- Identification of dissection initiation point</td>
<td></td>
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<tr>
<td>TEE</td>
<td>- Sensitivity 98%</td>
<td>- Difficulty in imaging distal ascending aorta and proximal arch</td>
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<tr>
<td></td>
<td>- Fast (9-18 min)</td>
<td>- Difficulty in evaluating branch vessel involvement</td>
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<tr>
<td></td>
<td>- Bedside</td>
<td>- Operator dependent</td>
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<tr>
<td></td>
<td>- Superior cardiac functional detail</td>
<td>- Hemodynamic effects: Increased BP/HR potentially resulting in death</td>
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<tr>
<td></td>
<td>- Aortic insufficiency</td>
<td></td>
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<td></td>
<td>- Ventricular function</td>
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<td></td>
<td>- True/false lumen</td>
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<td></td>
<td>- Able to identify pericardial and pleural effusions</td>
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Abbreviations: CT, computed tomography; MRI, magnetic resonance imaging; TEE, transesophageal echocardiography; AI, aortic insufficiency; BP, blood pressure; HR, heart rate.
at the task, can provide data on the presence of aortic insufficiency with the stipulation that this information typically requires an additional 15 minutes of exam time. Additionally, MRI is the most reliable method compared to CT and TEE at avoiding false-positive findings. However, it rarely is used as the initial imaging modality, given that it requires more time to perform than all the other imaging techniques, with average times between 23 and 39 minutes in 1 study, is not possible in patients with implanted metal devices, and can be difficult in hemodynamically unstable patients. Moreover, it presents obvious difficulties in monitoring of patients during the exam itself.

TEE has been shown to be equally effective in the diagnosis of type-A dissection as compared to CT and MRI. In pooled data, it has a sensitivity and specificity of 98% and 95%, respectively. It has the ability to be performed relatively fast at the bedside in hemodynamically unstable patients with performance times of 9 to 18 minutes and an average time of 13 minutes. It is highly efficacious at identifying the true and false lumen via the use of color-flow Doppler as well as identifying the dissection entry site and extent of dissection. In addition, TEE can be used to evaluate for additional typical findings associated with aortic dissection, including the presence of pericardial effusion, and is superior at identifying aortic insufficiency. TEE also provides relevant information on overall cardiac function. It is readily available in the operating room and can be performed under general anesthesia to confirm the diagnosis of aortic dissection. Diagnostic limitations of TEE in the evaluation of dissection occur when the dissection involves only the distal ascending aorta or proximal arch as these areas represent a blind spot for TEE due to tracheal overlay near this location. Additionally, this site typically involves the location of arterial branch points off the aortic arch; therefore, diagnosis of arterial vessel involvement represents another limitation of TEE.

TEE is a semi-invasive procedure that can result in hemodynamic changes in the patient during performance, including hypertension and tachycardia, which can further propagate the dissection, leading to potential death and, therefore, should be done in the presence of individuals capable of managing these hemodynamic shifts. Generally, TEE can be more observer/experience dependent as compared to the other 2 imaging modalities, leading to false-positive and false-negative findings if misinterpreted.

Given the risk of misinterpretation of TEE data, knowledge of common artifacts and how to distinguish them from true pathology are imperative when using TEE for diagnosis of ascending aortic dissection as there are substantial consequences of surgical intervention in the setting of normal anatomy. In the ascending aorta, linear artifacts can occur particularly in the presence of a dilated ascending aorta. Artifacts in the aortic root often result from reverberation from the anterior wall of the left atrium and can appear within the lumen of the vessel if the diameter of the aorta is greater than the diameter of the left atrium. A significant percentage of artifacts in the middle third of the ascending aorta are secondary to reverberations from the posterior wall of the right pulmonary artery. Common artifacts also can result from extensive plaque in the aorta as well as side-lobe artifacts from pulmonary artery catheters appearing in the ascending aorta, all of which can be confused with a dissection flap. Artifacts noted on TEE frequently have common characteristics. Extension of echogenic objects outside the normal anatomic boundaries suggests artifact. The use of biplane or multiplane probes aids in the identification of artifact with the ability to view multiple planes, as artifacts typically appear in a limited number of views. M-mode echocardiography can be used to identify reverberation artifact by noting the distance from the transducer to the object causing the artifact. For example, a reverberation linear image in the aortic root resulting from the left atrium can be measured and noted to be double the distance from the transducer as to the left atrium. In addition, color-flow Doppler can be helpful in evaluating blood flow on either side of the suspected dissection, which should be different in cases of a true dissection. However, some studies have demonstrated different blood flow patterns on either side of an artifact secondary to eccentric jets from valvular disease. Moreover, 6% of ascending aortic dissections can have the same blood flow pattern within the true and false lumen.

Overall, TEE offers substantial advantages in the diagnosis of ascending aortic dissection, particularly in gathering information for eventual surgical management in the operating room. Given the urgency of surgical intervention, early transfer of patients with high suspicion for a type-A dissection to the operating room may be prudent and result in improved outcomes. Once in the operating room, TEE can provide an accurate and thorough means of diagnosing or confirming a previously diagnosed type-A dissection prior to proceeding with surgery. Given the availability of TEE in the operating room and the ability of the cardiac anesthesiologist to not only perform TEE but also manage hemodynamic instability, early transfer to the operating room and increased reliance on TEE for initial diagnosis of aortic dissection could prove beneficial. However; as noted in the case of this patient, it is imperative to understand the limitations of TEE and be aware of the typical artifacts encountered in order to provide an accurate assessment of the findings.

Type-A aortic dissection represents a serious condition with substantial morbidity and mortality that requires prompt diagnosis and surgical treatment. There are several modalities, including CT, MRI, and TEE, which can be used with similar sensitivity in the diagnosis of type-A dissections. An understanding of common artifacts that can occur with the various imaging modalities is essential to the care of this patient population. The authors’ case represents a patient who was transferred to their institution for surgical management of a suspected ascending aortic dissection based on CT findings, with subsequent TEE demonstrating a common artifact but lack of a true dissection. Knowledge of echocardiography artifacts in this case prevented unnecessary sternotomy and surgical exploration in this patient.

**EXPERT COMMENTARY**

Facing a Patient With Suspected Acute Type-A Aortic Dissection in the Operating Room: A Case for Mandatory TEE Prior to Incision

“There is no disease more conducive to clinical humility than aneurysm of the aorta”  

—William Osler

*Edward Gologorsky, MD, FASE*
It was told by Homer that Odysseus nostos from Troy took his crew to the narrow Straits of Messina guarded by two monsters. Should their ship veer too close to Charybdis, then it would be lost in a gigantic whirlpool. Should they attempt to steer farther away from Charybdis, then the hapless travelers would be devoured by the hideous Scylla. The risk optimization problem faced by the master strategist required extraordinary intelligence, mental agility, and steadfastness. In the end, Odysseus was able to skirt the whirlpool of Charybdis at a unique distance and speed that prevented Scylla from devouring most of the crew.

Management of a patient with suspected ascending aortic dissection (AAD) is an example of such a risk optimization conundrum facing the modern physician. No margin for error exists, as the gamut of outcomes ranges from the cost and morbidity of an unnecessary sternotomy in case of a false-positive determination to the morbidity and mortality associated with the missed or delayed diagnosis and treatment of an acute AAD. Needless to say, the human cost and the medical liability may be devastating, particularly in the latter case.

Drs. Lanigan and Chaney described a patient who was emergently brought to the operating room for surgical repair of an AAD suspected clinically and identified by CT scanning. TEE performed immediately after induction of general anesthesia just prior to incision saved this patient from joining the ranks of VOMIT (Victims of Medical Imaging Technology). The theme of their presentation: CT images suggestive of AAD in a patient suspected of AAD, but in whom no aortic pathology was found intraoperatively upon echocardiographic or surgical examination, has been discussed extensively both formally and informally, by radiologists and surgeons in the context of the analysis of misread imaging studies. As Odysseus learned from the Argonauts’ experience, following the saga of the presented patient will reach some guiding considerations.

Acute AAD is rightfully considered a “Great Masquerader” because of the great variety of its clinical presentation and the breadth of the differential diagnosis. It is astonishing that this lethal disease, with a mortality rate of 1% to 4% per hour, is so frequently diagnosed postmortem or incidentally by an imaging modality performed for another reason (in up to 55% of the cases). Clinical symptoms may be absent in almost 20% of the patients. If present, they may range from sudden hemorrhagic compromise due to acute severe aortic insufficiency and tamponade, to various protein signs and symptoms stemming from the effects of target organ malperfusion and dysfunction, such as chest pain, visual, and neurologic defects. A history of hypertension and of a sudden onset of chest pain in the described patient all feature low likelihood ratios for the AAD. Assuming their absence, the patient reasonably could have been stratified into the low (no predictors) or intermediate (fewer than 3 independent predictors) risk group for AAD based on the acute onset of severe anterior chest pain with concomitant nausea and vomiting.

Even though the presence of “aortic” tearing pain is one of the classic symptoms of the AAD, chest pain per se is a nonspecific finding and may be misinterpreted as a manifestation of an acute coronary syndrome, especially in the presence of electrocardiographic changes and positive troponin levels. Such patients may be misdirected to the cardiac catheterization laboratory rather than to CT or echocardiography laboratory, leading to delayed diagnosis and potentially inappropriate antithrombotic, fibrinolytic, and antiplatelet therapies. Similarly, the dyspnea that accompanied the chest pain in the described patient is another known confounder and predictor of delayed in-hospital diagnosis because it often leads towards investigation of an underlying pulmonary pathology or pulmonary embolism rather than AAD. Therefore, Elefteriades et al proposed a “triple rule-out” CT scan as a sensitive diagnostic modality in circumstances when a differential diagnosis included all 3 life-threatening conditions: AAD, myocardial infarction, and pulmonary embolism.

Currently, the only biochemical test that would have allowed for the stratification of the described patient and narrowing of the differential diagnosis is the D-dimer assay. Measured within 24 hours of onset, it has been shown to have a negative likelihood ratio of 0.07 and a negative predictive value of 95% at the negative cut-off value of 500 ng/mL. However, 2010 guidelines do not recommend the use of D-dimer assay in prospective screening due to a lack of prospective studies and the potential for decreased D-dimer levels in patients with thrombosed false lumen and intramural hematoma. Conversely, a rule-in value of 1600 ng/mL within 6 hours of presentation may identify patients with high likelihood/probability of AAD but did not discriminate between AAD and pulmonary embolism. Therefore, it remained plausible that low values of D-dimer could have prompted the re-evaluation of the CT data and determination of an erroneous false-positive reading.

The presented CT images, while of satisfactory quality, were misread as indicative of AAD due to the fine crescent-shaped artifact on the left anterior surface of the ascending aorta. Understanding the mechanism of such pitfalls is important. Cardiac contractions result in a subtle aortic distention by the stroke volume (circular phasic movements), concurrent with slight pendular (perpendicular to the arch) motion of the ascending aorta due to the “swinging” phasic movements of the left ventricle in the pericardium. CT scanners with exposure times approximating the cardiac cycle allow detection of these systolic and diastolic motions of the ascending aorta if the pulse rate is coincident with the rate of imaging. Seen as a soft curvilinear shadow projected inside the lumen of the ascending aorta, such motion artifact may be mistaken for a smooth crescent-shaped intimal flap. The right posterior and left anterior aspects of the proximal ascending aorta imaged in the transverse axial plane most commonly are affected. Conversely, areas such as the right anterolateral aspect of the ascending aorta, which experience the maximal pressure fluctuations (dP/dt) are more likely sites of the true intimal tears. Such tears are likely to be accompanied with mediastinal or intramural hematoma, absent in the presented image.
Virtual “rescanning” from the acquired data set changing the time intervals between the images, such as retrospective electrocardiographic-modulated cardiac gating, may prove helpful in differentiating a motion artifact from a true AAD, but this has not been validated in emergency evaluations of suspected acute aortic syndromes.21,20

Therefore, this patient was brought to the operating room emergently for repair of AAD suspected on the basis of a seemingly atypical clinical presentation and diagnosed by thoracic CT by the presence of a soft curvilinear shadow in the transverse axial plane over the left anterolateral aspect of the proximal ascending aorta. In the presentation, the patient had definitive diagnosis made by TEE after induction of general anesthesia but serendipitously prior to incision. Had a TEE-trained anesthesiologist not been present in the operating room, the correct diagnosis would have been made surgically, typical for a VOMIT scenario.

TEE performed under general anesthesia with secured airway and beat-to-beat blood pressure monitoring allows for a comprehensive cardiac examination and a thorough evaluation of the aortic root, ascending aorta, pericardium, and aortic valve function. Additionally, pre-incisional TEE is paramount in identifying the site of intimal tear (with a sensitivity 78%-100%), true and false lumens and communications between them, assessing myocardial regional wall motion abnormalities, and determining the origins of the coronary ostia in the false or true lumen. Furthermore, TEE allows for the relatively straightforward identification of hemopericardium and for the quantification of the severity of aortic insufficiency, as well as its mechanism.21 These advantages led a major teaching medical center to adopt a paradigm for the management of type-A aortic dissection centered on direct operating room admissions and intraoperative echocardiography in cases of suspected AAD.20,21 Thus, in these series, echocardiography was the primary diagnostic modality in 51.9% of the cases and CT in 36.9%, reversing the trend reported by the International Registry of Acute Aortic Dissection. Interestingly, out of 361 patients stratified as high-risk and admitted directly to the operating room, 16 had a normal TEE exam, including 2 with CT findings recognized as artifact.

Disadvantages of intraoperative TEE under general anesthesia and beat-to-beat controlled/monitored hemodynamics include its operator dependency and a relatively high rate of artifacts. As Dr. Lanigan and Dr. Chaney observed, a thorough understanding of the physical phenomena (such as reverberations from the left atrium and right pulmonary artery located posteriorly to the ascending aorta) is mandatory in the high-stakes echocardiographic evaluation of a suspected AAD. The presence of a linear image superimposed on the lumen of the ascending aorta in the midesophageal short-axis view is common, is not considered diagnostically significant, and requires a differential diagnosis to distinguish it from a true intimal flap. Expertise and experience are required to appreciate the differential characteristics. Dr. Lanigan and Dr. Chaney review those features related to the genesis of the artifacts, such as the relative distances of the relevant reflective surfaces and the corresponding linear artifacts from the transducer (and the use of M-mode in making that determination). This author would add that in grayscale the artifacts are usually thicker than the true intimal flaps, are less echogenic, and have poorly defined borders, extending outside the anatomic structures. These artifacts frequently are seen as horizontal lines parallel to the wall of the aorta regardless of the angle of the insonation and do not demonstrate phasic oscillatory movements characteristic of the intraluminar flaps. With very few exceptions, upon Doppler examination, the blood flow may be seen as superimposed on the linear artifact and is laminar, and the velocity and direction of blood flow are similar on both sides of the artifact. Absence of identifiable intimal tears, hemopericardium, and acute aortic insufficiency may help focus the questionable linear image into proper perspective. Similar to CT, an inexperienced novice may mistake various periaortic structures with soft boundaries opposing the aortic walls, such as the right atrial appendage, superior vena cava, or thickened pericardial recess, for an intraluminar membrane in the ascending aorta.

Although the sensitivity of TEE in type-A aortic dissection approaches 99% in experienced hands, an understanding of the operator-independent limitations of TEE is important, such as interposition of the air-filled trachea and left bronchus between the transducer and the parts of the distal ascending aorta, proximal arch, and arch vessels. Additionally, certain rare types of aortic dissections may not be demonstrable with either imaging modality.21,24

This author has described the analysis of false-positive and false-negative CT readings of AAD in the context of clinical presentations. High negative predictive value of TEE allowed the surgery to be postponed in favor of further studies in a hemodynamically stable patient with low pretest probability, circumstances similar to those described by Dr. Lanigan and Dr. Chaney. Conversely, in a hemodynamically unstable patient with a pericardial effusion and high pretest probability, a diagnostic TEE was performed despite a (false) negative CT. Successful management of suspected type-A aortic dissection described by Chavanon et al11 similarly is predicated on the intraoperative echocardiographic diagnosis in anesthetized, closely monitored patients triaged according to the probability of the aortic dissection. Therefore, the current practice in the authors institution is to perform a thorough pre-incisional TEE under general anesthesia with direct arterial blood pressure monitoring in patients stratified as high probability for AAD based on the clinical presentation regardless of CT reading. Their intraoperative set-up is different from that described by Dr. Lanigan and Dr. Chaney only in that similar to Chavanon et al, this group routinely initially cannulates the right radial artery rather than the left for anatomic reasons.

In conclusion, this commentator believes that the presentation by Dr. Lanigan and Dr.Chaney further confirms the validity of performing a comprehensive TEE examination in the cardiac operating room under general anesthesia with direct blood pressure monitoring and beat-to-beat control both in patients with low pre-test probability and questionably positive CT data and in patients with high pre-test probability of clinically suspected AAD regardless of CT reading. The opportunity for an immediate potential life-saving surgical intervention is achieved at a relatively nuisance price of an operating room set-up, general anesthesia supplies, and some invasive catheter placement. That’s a choice worthy of Odysseus.
EXPERT COMMENTARY 2†

This case history is informative and sheds light on the difficulties of emergency management of aortic dissection. In this life-threatening situation, decisions have to be made quickly, and the surgical sanction is heavy. This comprehensive update provides a perfect summary of the pros and cons of the various imaging possibilities with a useful review of possible traps and artifacts.

Although AAD is an ever-present concern for cardiac surgeons and cardiologists, it is far less common than coronary emergencies, accounting for only 3 in every 1,000 patients admitted with back or chest pain25 or 1 in every 10,000 emergency admissions in the United States.26 It has been estimated that aortic dissection initially is suspected in less than half of all patients ultimately diagnosed with it.26 The issue is, therefore, an important one for the front-line physicians who are the first to see these patients, especially when it comes to avoiding unnecessarily subjecting patients to expensive, invasive tests. Although typical symptoms are well characterized, presentation is often atypical, eg, there may be no pain,25,27 and this can lead to a delayed diagnosis.28 This is the reason for using the Aortic Dissection Detection Risk Score29, which is based on 12 items that can be scored at the bedside. These are split among 3 categories, namely risk factors (ascertained by talking to the patient), the nature of the pain, and the results of a physical examination. The patient’s risk is graded between 0 (unlikely) and 3 (high risk) with an algorithm designed to guide which tests to perform on the basis of the risk. Validation of this score by the International Registry of Acute Aortic Dissection26 showed that, while sensitivity is good (with 95.3% of registered patients fulfilling at least 1 criterion), specificity remains undemonstrated. Pharmacologic treatment and surgery should be undertaken as soon as possible to prevent deterioration towards cardiac tamponade or rupture, which account for 41.6% of mortality.25 Regional organization covering diagnostic algorithm, therapeutic protocols, and logistics is required. Antimipulse therapy includes a first-line beta-blocker (to keep blood pressure below 120 mmHg), and a vasodilator may be added. By lowering Dp/dt, the beta-blocker reduces the risk of aortic rupture,18 but unfortunately, a vasodilator on its own still is prescribed too often. What could be worse than losing a patient during CT scanning or transfer? It is estimated that 75% of AADs are diagnosed in small hospitals,29 so the logistics need to be organized as a care network to channel patients as quickly as possible towards centers specializing in this type of surgery and to ensure best-available multidisciplinary care.30,31 This will require a team of surgeons and anesthesiologists together with experienced interventional radiologists for complementary endovascular procedures to correct malperfusion, possibly before surgery as with intestinal malperfusion.30 The author’s system organized as a regional care network, has allowed surgery on 2/3 of all patients with acute type-A aortic dissection within 24 hours of the onset of symptoms.30

From the simplest test, like chest radiology (with mediastinal enlargement present in 63% of cases),27 to the most sophisticated, all tests have their pros and cons. Transthoracic echocardiography should be considered because it can be performed at the bedside and often provides information on the aortic dissection, aortic insufficiency, and the condition of the pericardium and left ventricular function. Special attention should be paid to the suprasternal approach, which sometimes can provide information about the ascending aorta.31 The abdominal aorta is visualized easily to confirm the diagnosis of dissection leaving only investigation of involvement of the ascending aorta. Depending on the degree of uncertainty, TEE can be undertaken with the patient sedated or even under general anesthesia to prevent hypertension and passage to tamponade. This examination is more precise and identifies lesions outside the blind area. Morphologic data are important and dynamic data are essential. However, TEE is operator-dependent and there is no systematic sampling and storage of findings outside of the recorded loops. In contrast, helical CT scanning allows 3-dimensional sampling and data storage for review and reanalysis on the computer screen. The possibility of sending images over the Internet means that the opinion of the patient’s radiologist can be sought if there is any doubt. In addition, although surgeons may know how to interpret echocardiographic images, they are more familiar with CT results. Finally, the technique of 3-dimensional TEE is more sensitive and detects cases missed in 2-dimensional TEE;32 its increasing use is enhancing diagnosis.

The major advantage of CT scanning is that it yields a full cervico-thoraco-abdominal picture of the dissection and shows any malperfusion that can impact therapeutic strategy and help the surgeon plan the operation, eg, where to insert the cannula and how much to resect. If no preoperative CT scan is available, one should be obtained as soon as possible after surgery to screen for residual malperfusion, especially in the kidneys so that endovascular treatment can be carried out to rescue renal function. MRI has no place in the emergency situation, but it can be useful for long-term postoperative monitoring or monitoring patients with a type-B dissection.

Multiple tests often are carried out to complement the CT scan, and, once the patient has been anesthetized for surgery, TEE always should be carried out to confirm the diagnosis, as well as for the additional information it provides. Some 70% of International Registry of Acute Aortic Dissection patients had both examinations,25 and the proportion is the same among this author’s patients.10 If there is any doubt, the tests should be repeated, passing from one modality to another and recording a new CT scan if necessary33 to decrease the risk of unnecessary sternotomy because of a falsely positive finding.33

The problem of diagnostic traps is also explained clearly in this article. While reverberation artifacts in echocardiography are well known, CT scans too can be imperfect. This problem is being mitigated by improvements in the resolution of the machines and cardiac synchronization, but false images are still possible. As well as technical factors and artifacts, an aortic diverticulum or ulcer can be misinterpreted, although these are quite different entities. Moreover, anatomic structures around the aorta may be misinterpreted, eg, neighboring mediastinal vessels, a pericardial recess, a residual thymus, atelectasia, and pleural abnormalities for the descending aorta.33,34,35 Careful

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analysis of serial sections on the computer screen will often reveal continuity with another anatomic structure and it may be necessary to go back to the raw data on the original CD-ROM as well as examining the selected, copied sections.

In echocardiography, the operator’s experience is key, and the diagnosis may have to be based on Doppler flow analysis, or and according to the presence or absence of other signs, eg, pericardial effusion or aortic insufficiency. The case reported here is emblematic in this sense because there were artifacts on both the CT scan and the TEE. It was the operator’s experience that led to reassessment of the initial diagnosis, which was ultimately ruled out by the second scan. Conversely, if the dissection is focal, the opposite mistake can be made with presumption of a CT artifact. This author recently had a patient referred to him with chest pain and suspected acute coronary syndrome. The results of coronary angiography were normal and the CT scan showed a highly focal dissection (which could have been taken as an artifact) with pericardial effusion. The patient was anesthetized, but TEE showed a normal ascending aorta (and confirmed the pericardial effusion). Since pericarditis was a possibility, they decided to obtain another CT scan, which confirmed the initial diagnosis. Another danger is too much thinking, which can lead to compensatory excess.

**COMMENTARY 3: ANESTHESIA/CRITICAL CARE EXPERT**

The advent of diagnostic computed tomography (CT) for rapid evaluation of acute chest pain has resulted in imaging protocols for the triple rule-out of acute coronary syndrome, pulmonary embolism, and aortic dissection. Furthermore, the development of electrocardiographically gated CT aortic imaging has minimized the motion artifacts of the ascending aorta, which can be misinterpreted for type A aortic dissection. As a result of these advances in aortic imaging, patients increasingly present to the operating room with the diagnosis of type A aortic dissection (based on a CT scan) for emergency surgery, as in this case conference.

In this clinical scenario, the first priority of the anesthesia team is to stabilize the patient, especially if the suspected acute aortic syndrome presents with unstable hemodynamics. The second priority in this scenario is the rapid but comprehensive evaluation of the thoracic aorta with transesophageal echocardiography (TEE) to confirm or refute the diagnosis of acute type A aortic dissection. If the diagnosis is confirmed, then immediate surgical repair is undertaken as per the institutional protocol. If the diagnosis is refuted by TEE with an experienced operator, the management of false positive presentations may, nevertheless, still be challenging.

If the patient with a false positive presentation is clinically unstable, then key findings on the TEE examination may assist not only in the diagnostic evaluation but also in the therapeutic management. For example, a false positive presentation for acute type A dissection actually can be an acute coronary syndrome that may require aggressive resuscitation with inotropes, intra-aortic balloon counterpulsation, and prompt transfer to the cardiac catheterization laboratory for emergency coronary stenting. In the perioperative paradigm with direct admission to the operating room for management of acute aortic syndromes, it is essential that the operating room functions both as a diagnostic and therapeutic suite, regardless of preoperative aortic imaging.

False positive presentations also can be acute variants of classic acute type A aortic dissection such as intramural hematoma (IMH). This acute aortic syndrome is defined as localized hemorrhage within the aortic wall and accounts for up to 20% of acute thoracic aortic presentations. The TEE examination typically distinguishes this variant by demonstrating distinct mural thickening in the thoracic aorta. Type A IMH is by definition within the ascending aorta with a variable distal extent. Although surgical intervention is typically indicated on an urgent basis, indications for immediate surgical management include mural thickening >10 mm, aortic diameter >5cm, concomitant pericardial effusion suggesting aortic rupture, pericardial tamponade, imaging evidence of rebleeding, and/or evidence of thrombus extension on serial imaging. All these high-risk features can be delineated by comprehensive TEE assessment of the thoracic aorta and, hence, are essential in the detailed assessment of IMH presentations to the operating room. A recent analysis from the International Registry of Aortic Dissection reported that type A IMH is more likely to be associated with periaortic hematoma and pericardial effusion than classic type A aortic dissection.

Excellent communication between the intraoperative echocardiographer and the rest of the perioperative team remains essential to high-quality decision-making in the diagnosis and management of acute aortic syndromes, including classic acute type A dissection. An integrated approach in this setting can further minimize the delay from clinical presentation to definitive management, whether surgical or otherwise.

Another false positive presentation in this setting that merits consideration is penetrating atherosclerotic ulcer (PAU), typically included in the spectrum of aortic dissection. In this disorder, the atherosclerotic plaque ulcer disrupts the intima to burrow into the aortic media, which then is exposed to pulsatile arterial blood flow. The complications associated with PAU include IMH, localized dissection, pseudoaneurysm, and aortic rupture. The typical clinical presentation of PAU is in the elderly hypertensive patient with extensive aortic atheroma evident on TEE. Although the descending thoracic aorta and abdominal aorta are the most common sites of PAU, it can also present in the ascending aorta or aortic arch. The presence of PAU in the ascending aorta, even if asymptomatic and without complications, is still regarded as an indication for early intervention. Depending on the clinical circumstances, endovascular or conventional surgical repair may be chosen. If conventional surgical repair is selected, the comprehensive evaluation of aortic atheroma in real time by the echocardiographer can significantly guide arterial cannulation for cardiopulmonary bypass. Given the aortic atheromatous burden in this clinical scenario, alternative cannulation sites such as the innominate and axillary artery offer the opportunity to decrease the risks of cerebral atheroembolism and clinical stroke.

A rarer entity that may present with aortic findings such as wall thickening in the operating room is large vessel vasculitis, defined as arteritis that predominantly involves the aorta and its...
major branches.\textsuperscript{51,52} The most common primary large vessel vasculitis in older adults in Western Europe and North America is giant cell arteritis. This arteritis is frequently associated with polymyalgia rheumatica and may affect the carotid artery and its branches. Acute steroid therapy may be required to treat ophthalmic arteritis to prevent blindness.\textsuperscript{53} Recent data suggest that the risk of clinical thoracic aortic involvement with aneurysm or dissection in giant cell arteritis is at least 5\% to 10\%.\textsuperscript{53,54} The histology of this arteritis is the source of its name, because it is characterized by the presence of granulomas typically accompanied by giant cells.\textsuperscript{51,52}

Although it has similar histology to giant cell arteritis, Takayasu arteritis is a less common primary vasculitis that typically affects younger women of Asian origin.\textsuperscript{51,52} Although it can lead to aneurysm and dissection in the thoracic aorta, it more commonly presents with symptoms of acute and/or chronic arterial occlusion that can make placement of an arterial line very challenging.\textsuperscript{55} Coronary artery involvement within this disease can present with acute chest pain that may be confused with pulmonary embolism or aortic dissection.\textsuperscript{56,57} A high index of suspicion is required to avoid mortality from this type of acute coronary syndrome in young women.\textsuperscript{56,57} Aortitis also is associated with known rheumatic diseases, such as systemic lupus erythematosus.\textsuperscript{58} This may result in aneurysm and/or dissection in the thoracic aorta.\textsuperscript{58,59} Recent analysis suggests that there are two distinct aortic mechanisms in this disease: the first being an aortitis with cystic medial necrosis and the second being atheromatous degeneration secondary to chronic steroid therapy.\textsuperscript{59} The systemic nature of this disease may result in clinical presentations beyond the aorta such as pericarditis, myocarditis, and even endocarditis.\textsuperscript{58,59}

In summary, TEE is an essential tool in the diagnosis and management of patients presenting to the operating room with a suspected acute aortic syndrome. The perioperative echocardiographer should keep in mind the differential diagnosis in the setting of a false positive presentation. The clinical priorities remain the same in this setting whether the patient has a type A dissection or not: correct diagnosis, cardiorespiratory stabilization, and selection of the correct intervention. In this management algorithm, TEE remains indispensable.

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