

Initial Triage and Management of Patients with Acute Aortic Syndromes



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KEYWORDS

- Acute aortic syndrome • Aortic dissection • Intramural hematoma • Penetrating aortic ulcer
- Blunt traumatic thoracic aortic injury • Vascular emergency

KEY POINTS

- Acute aortic syndromes (AAS) encompass life-threatening conditions like aortic dissection, intramural hematoma, penetrating aortic ulcer, and traumatic thoracic aortic injury.
- AAS often manifests with classic ripping or tearing chest pain; however, diverse symptoms such as syncope, shock, or organ dysfunction may also occur. Therefore clinicians should maintain a high index of suspicion.
- Timely diagnosis of AAS is crucial for initiating life-saving treatment; clinicians must remain vigilant and integrate patient presentation, comorbidities, and pre-test probability to guide diagnostic and therapeutic decision making.
- High-risk patients require immediate treatment, even before diagnostic imaging is completed. Acute treatment typically includes intravenous beta-blockers, vasodilators, and pain control to reduce heart rate and blood pressure.
- Surgical intervention for AAS is often necessary and should be tailored to patient anatomy and the extent of vascular compromise. A comprehensive approach to management is required.

INTRODUCTION

Acute aortic syndromes (AAS) are highly lethal vascular emergencies involving disruption of the aortic wall. First described by Morgagni in 1761 as a cause of death in a patient who suffered fatal pericardial tamponade after an aortic dissection (AD), AAS continued to remain a lethal disease without treatment until DeBakey, Cooley, and Creech described successful surgical repair techniques in 1955.¹ AAS represent a syndromically related series of diseases which include AD, intramural hematoma (IMH), and penetrating aortic ulcer (PAU); blunt traumatic thoracic aortic injury (BTTAI) results from a different mechanism but carries important similarities.² These conditions require urgent evaluation, prompt diagnosis, and

emergent treatment which often includes surgical repair.

PATHOPHYSIOLOGY AND RISK FACTORS

The common pathophysiologic factor uniting all AAS is damage to the integrity of the aortic wall. ADs comprise the vast majority of AAS (85%–95% of all cases).³ In acute AD, intramural hemorrhage with infiltration of blood products into the medial layers of the aortic wall results in the creation of a dissection plane with propagation of blood into a false lumen (Fig. 1).⁴ Often, the inciting event is a tear in the intimal layer of the vessel wall which results in blood tracking along a dissection plane in the media. Aortic rupture can occur if the adventitial layer is disrupted. A second intimal

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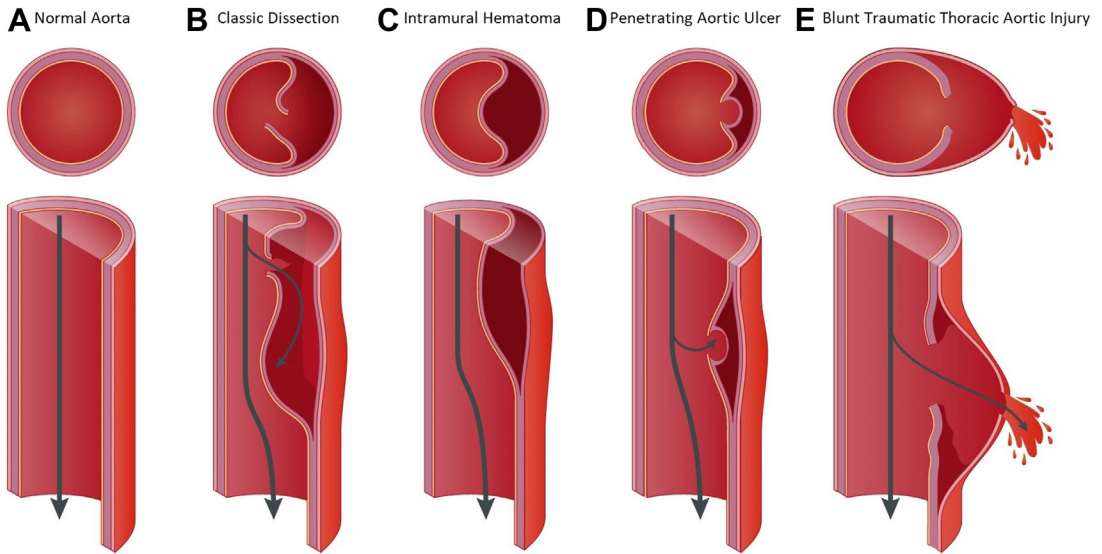


Fig. 1. Types of acute aortic syndromes. (A) Regular aorta with intact vessel wall. (B) Classic aortic dissecting with disruption of medial layer allowing blood propagation with creation of true and false lumens separated by intimal flap. (C) Intramural hematoma creating separation between medial layers without intimal tear or blood propagation. (D) Penetrating aortic ulcer with disruption of intima and penetration into media. (E) Blunt thoracic traumatic aortic injury with disruption of all layers of the vascular wall. (From Bossone E, Eagle KA. Epidemiology and management of aortic disease: aortic aneurysms and acute aortic syndromes. *Nat Rev Cardiol.* May 2021;18(5):331-348. doi:10.1038/s41569-020-00472-6).

tear sometimes occurs, allowing re-entry of blood back into the true lumen from the false lumen. The dissection plane itself can propagate proximally and/or distally and involve branch vessels coming off the aorta. If this occurs, vascular compromise, stenosis, or occlusion with tissue ischemia, and end-organ injury can result.

There are a number of heritable and/or genetic syndromes (Box 1) which result in abnormalities to the aortic media and thereby increase the risk of AD; among the most common is bicuspid aortic valve with associated aortopathy, given that bicuspid aortic valve is the most common congenital cardiac abnormality.⁵ It is important to identify associated conditions as their presence can inform screening of close relatives; indeed, a family history of AD is a major risk factor for AAS.^{2,6} Additionally, nonheritable risk factors which increase wall stress or contribute to compromise in wall integrity can also help precipitate AAS (see Box 1). Often, these are associated with increased aortic diameter.^{2,7-10} Many are modifiable risk factors which offer therapeutic opportunities for intervention. Clinicians should be cognizant of such associated conditions and risk factors in dealing with patients with suspected AAS. The majority of cases of AD occur in males, with a mean age of 63 year old. Dissections are more common in the morning hours, between 6:00 AM and 12:00 PM, as well as in the winter months, suggesting

that the circadian variation in varying physiologic processes (eg, the morning adrenergic surge) contributes to the development of AD.

Pregnancy represents a uniquely vulnerable period where hormonal and hemodynamic changes increase the susceptibility to AD, especially in women with underlying aortopathy or aortic dilation.^{2,11} Dissection can occur anytime throughout pregnancy; however, it most commonly occurs within the third trimester (often Stanford type A) or within the first 12weeks post-partum (often Stanford type B) due to increases in blood volume expansion, heart rate, stroke volume, and neuro-hormonal activity which peaks during this time period.¹¹ Prophylactic aortic surgery prior to conception is recommended to decrease the risk of AD in individuals with pre-existing aortopathy and aortic dilation, although size cutoffs vary based on underlying condition.²

Aortic dissection (AD) can occur iatrogenically during percutaneous intravascular procedures, where an intimal tear results from procedural manipulation and disruption, often with retrograde propagation of the dissection plane (eg, proceeding cephalad from femoral access), unlike most spontaneous AD where antegrade blood flow propagates the dissection caudally. Iatrogenic AD is most commonly precipitated by trauma from catheter maneuvering, balloon inflation, contrast injection, and guidewire manipulation.¹² Procedural

Box 1**Clinical syndromes associated with increased wall stress or vascular media weakness contributing to acute aortic syndrome**

Heritable Conditions Associated with Vascular Wall Abnormalities

- Marfan Syndrome
- Loeys-Dietz Syndrome
- Vascular Form of Ehlers-Danlos Syndrome
- Meester-Loeys Syndrome
- LOX-related Thoracic Aortic Syndrome
- Familial Thoracic Aortic Aneurysm (and dissection) Syndrome
- Bicuspid Aortic Valve (with aortopathy)
- Turner syndrome

Clinical Factors Associated with Vascular Wall Abnormalities

- Rheumatologic and Non-Infectious Inflammatory Conditions
 - Takayasu arteritis
 - Rheumatoid arthritis
 - Temporal arteritis
 - HLA-B27 associated spondyloarthropathies (ankylosing spondylitis, reactive arthritis)
 - Cogan's syndrome
 - Relapsing polychondritis
 - Systemic lupus erythematosus
 - Behçet's disease
 - ANCA-related vasculitis (Polyarteritis Nodosa, Microscopic Polyangiitis, Granulomatosis with Polyangiitis)
 - Juvenile idiopathic (rheumatoid) arthritis
 - Idiopathic aortitis and inflammatory aortic aneurysms
 - Sarcoidosis
 - Giant Cell Arteritis
 - IgG4-related disease
- Infectious Conditions
 - Bacterial aortitis (*Salmonella spp*, *Staphylococcus spp*, *S spp*)
 - Syphilitic aortitis
 - Mycobacterial aortitis
 - Fungal aortitis
- Other Clinical Factors Associated with Vascular Wall Abnormalities
 - Atherosclerosis
 - Pregnancy

- Polycystic kidney disease
- Chronic steroid use
- Tobacco use
- Diabetes

Clinical Factors Increasing Wall Stress

- Hypertension
- Pheochromocytoma
- Use of cocaine or other stimulants
- Vigorous Valsalva maneuvers (eg, weightlifting)
- Trauma, especially deceleration injury
- Aortic coarctation
- Aortic aneurysm

AD is most common during chronic total occlusion (CTO) procedures, in those with history of coronary artery bypass grafting, and during emergency catheterization.^{12,13} Overall, procedural AD is rare with a reported incidence of 0.02%.¹³ In many cases, procedural AD occurring at the coronary ostia can be managed by coronary stenting to prevent AD extension. However, in those cases where the dissection extends more than 40 cm into the ascending aorta, surgery is often necessary.^{12,13} In cases where the patient is hemodynamically stable, the origin is controlled, and the dissection is not expanding, it is reasonable to treat conservatively as the antegrade blood flow will compress the false lumen and help to resolve the hematoma in the setting of retrograde AD.¹²

IMH represents a confined hemorrhage into the wall of the aorta. Classically, it was believed that IMH resulted from hemorrhage from the *vasa vasorum* which had proliferated into an area rich with atherosclerotic plaque.^{14–16} Alterations in vascular loading conditions which result in changes in wall stress concentrated at the interface of the media and adventitia have also been postulated as a contributory factor to IMH development.¹⁷ This localized hemorrhage into vascular walls can propagate and develop into overt AD, and IMH can be considered a potential precursor to AD.¹⁸

Penetrating aortic ulcers result from rupture of an atherosclerotic lesion through the internal elastic lamina and allow for hematoma formation in the vascular wall.¹⁹ There can be varying degrees of compromise to the vessel wall from local penetration of the internal elastic lamina, to medial disruption with formation of IMH and dissection, to compromise of the adventitia and subsequent free rupture of the aorta.²⁰ However, in isolated PAU, it is speculated that medial fibrosis and chronic

atheromatous changes surrounding the lesion limit propagation of blood into the medial layer and prevent hematoma propagation.²¹

BTTAI results from rapid shearing forces exerting differential wall stress on adjacent regions of the aortic wall, most often at the isthmus where the arch becomes the mobile descending thoracic aorta (ie, just distal to the ligamentum arteriosum).^{20,22} This most often occurs during rapid deceleration injuries related to automobile crashes. The spectrum of vascular injury can vary from a simple intimal disruption to frank aortic rupture and has historically been associated with a high mortality rate.²⁰ Therefore, BTTAI arises from a distinct pathophysiological mechanism than other AAS, despite similarities in presentation and treatment.

CLASSIFICATION

AAS are classified based on their anatomic locations and time course. The DeBakey and Stanford classification schema are the most commonly used. The DeBakey system classifies AAS based on origin of the intimal tear and the presence or absence of involvement of the ascending aorta.^{4,23} In DeBakey Type I AD, the tear occurs in the ascending aorta and propagates distally to involve the arch extending into the descending aorta. In contrast, in DeBakey Type II AD, the tear and the dissection are confined to the ascending aorta alone. In DeBakey Type III AD, the tear and dissection occur in the descending aorta, with type IIIa having the dissection tear confined to only the descending thoracic aorta, and IIIb having the dissection extend below the diaphragm. The Stanford system classifies AAS based on involvement or lack of involvement of the ascending aorta, regardless of the site of origin. Stanford Type A dissections include all dissections which involve the ascending aorta, regardless of the location of the initial tear, and Stanford Type B dissections are those that do not involve the ascending aorta, including those that involve the aortic arch (Fig. 2A).²³ As such, Stanford Type A dissections essentially include both DeBakey Type I and II, and Stanford type B is functionally equivalent to DeBakey type III. IMH and PUD can also be classified using the DeBakey and Stanford systems based on the locations where they occur.² BTTAI is classified based on the degree of disruption aorta with Grade I consisting of an intimal tear, Grade II an IMH, Grade III a pseudoaneurysm, and Grade IV a rupture of the aorta itself (Fig. 2B).²⁰ The International Registry of Acute Aortic Dissection (IRAD) classifies AAS based on their time course into 4 distinct periods associated with worsening survival

as time progresses: hyperacute (symptom onset <24 hours), acute (2–7 days of symptoms), subacute (8–30 days of symptoms), and chronic (>30 days of symptoms).²⁴ Appropriate classification is important, as location and duration of the dissection influence survival and inform treatment strategies, particularly surgical approaches.

EPIDEMIOLOGY AND OUTCOMES OF ACUTE AORTIC SYNDROMES

IRAD data suggest that the majority of patients with AD present with Stanford Type A (67%) rather than Type B (33%) and that the differential type of AD confers different mortality and treatment strategies.^{10,25} Acute aortic dissection is highly lethal entity with a mortality of 1% to 2% per hour after symptom onset if it occurs in the ascending aorta, making it perhaps the most acutely life-threatening cause of chest pain.²⁶ Overall in-hospital mortality has fallen from 31.4% to 21.7% in Type A AD between 1995 to 1999 and 2010 to 2013, respectively, driven primarily by declining surgical mortality with the associated repair.²⁵ In this same analysis, mortality in Type B AD has remained roughly constant: 12.1% from 1995 to 1999 and 14.1% from 2010 to 2013 despite the greater use of endovascular management during these time periods.

IMH represents a less common cause of AAS. Although some series describe as high as a 10% to 30% incidence, IRAD reports a more conservative incidence of 6.3% in their large series of AAS.²⁷ IRAD data might represent an underestimation of true IMH incidence as it is gleaned from tertiary referral centers which might not capture IMHs diagnosed at community hospitals and not referred to IRAD centers. Groups in Asia report an incidence of IMH of up to 30%, reflecting heterogeneity in IMH prevalence and reporting between centers.²⁸ While ADs favor the ascending aorta, IMHs preferentially involve the descending aorta (40% Type A, 60% Type B).²⁹ IMHs either resorb, evolve into a contained rupture, form an aneurysm, or progress to AD, with older autopsy series noting 13% of patients had ADs that originated from IMHs.¹⁸ Both acute and chronic mortality for IMH are high (14% acutely, 12% over 3 months) and outcome is heavily influenced by maximum aortic diameter with larger maximum aortic diameters (>50 mm) conferring a worse prognosis.^{30–32} Similar to IMH, PAUs represent a rare cause of AAS with reports of their incidence ranging from 2% to 11%.^{28,33,34} The majority of PAUs are found in the descending thoracic aorta, followed by abdominal aorta, and aortic arch.³⁵ PAUs also occasionally evolve into AD, with

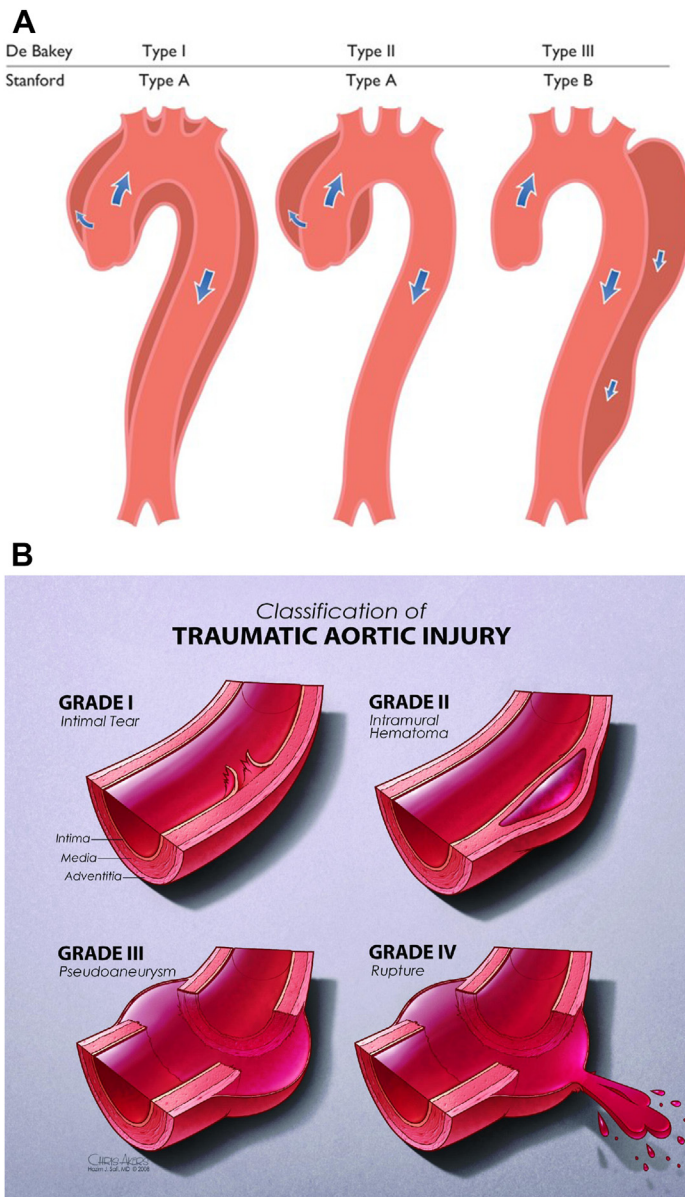


Fig. 2. Classification of acute aortic syndromes (A) Classification of aortic dissection, intramural hematoma, and penetrating aortic ulcer are based on the location of pathology. The DeBakey system classifies aortic pathology based on the location of the intimal tear. The Stanford classification is based on the involvement of the ascending aorta. Stanford A dissections involve the ascending aorta. Stanford B dissections do not involve the ascending aorta. DeBakey I dissections involve the ascending aorta and propagate distally. DeBakey II dissections are confined to the ascending aorta. DeBakey III involves the descending aorta. (B) Blunt traumatic thoracic aortic injuries are graded based on degree of compromise to the aorta. Grade I is an intimal tear, Grade II is an IMH, Grade III is a pseudoaneurysm, in Grade IV there is aortic rupture. (From Erbel R, Aboyans V, Boileau C, et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). *Eur Heart J.* Nov 1 2014; 35(41):2873-926. doi:10.1093/eurheartj/ehu28. <https://doi.org/10.1093/eurheartj/ehu28>; and Azzizadeh A, Keyhani K, Miller CC, 3rd, Coogan SM, Safi HJ, Estrera AL. Blunt traumatic aortic injury: initial experience with endovascular repair. *J Vasc Surg.* Jun 2009;49(6):1403-8. <https://doi.org/10.1016/j.jvs.2009.02.234>.)

autopsy series documenting that 5% of cases of AD originating from PAUs.³⁶

BTTAI is rare, accounting for 1.5% of thoracic trauma cases; however, it remains the second largest traumatic cause of death after head injury.³⁷ The majority (81%) of BTTAIs occur in the setting of automobile collisions. Despite the increasing use of safety measures such as seatbelts and airbags, there has been no change in the incidence of BTTAI.³⁸ It remains a highly lethal disease with the vast majority of patients dying before ever reaching a hospital (up to 80%).³⁷ Traditional BTTAI repair has been with an open surgical approach; however, there has been increasing adoption of thoracic

endovascular aortic repair (TEVAR) which has resulted in a reduction in operative mortality (16% surgical mortality with open repair, 9% with TEVAR) with fewer spinal cord injuries.³⁹ Despite this, in-hospital mortality has remained high, up to 46%.³⁷

PRESENTATION AND DIAGNOSIS

The AAS are often described as “great masqueraders” which can present with protean or non-specific symptoms necessitating a high index of suspicion. Classically, AD presents with chest pain (79%–83% of patients with Type A, 63%–71% of patients with Type B) that is abrupt in onset;

pain often radiates, for example, from the chest to the back.^{25,40} However, the presentation can be quite variable—while most patients endorse anterior chest pain or back pain, abdominal pain and migratory pain are also common presenting signs. The pain is typically rated as “severe” or “worst ever” with sharp, tearing, or ripping qualities; pain is often most intense at its onset, and a spontaneous improvement in pain over time can lead to a false sense of security. A minority of patients will present with syncope or cerebrovascular accident, and providers should always suspect AD in patients with “chest pain plus” syndromes involving non-thoracic symptoms plus thoracic pain.

Similarly, physical examination signs characteristic of AD might be subtle or not present at all, and physical examination alone is never sufficient to exclude AD. Patients are often hypertensive on initial evaluation; however, some can be normotensive, in congestive heart failure, in shock, or display tamponade physiology; the presence of a pulse deficit can mask hypertension or result in a blood pressure differential between limbs.⁴⁰ However, pulse deficits are found only in fewer than a third of patients and absence of unequal pulses does not exclude AD.^{25,40} A murmur of aortic insufficiency (due to dissection into the aortic root disrupting aortic valve coaptation) may be auscultated in patients with Type A dissection (44% of patients in the initial IRAD report) but is much less common in patients with Type B dissection (12% of patients) due to lack of aortic root involvement.⁴⁰

Patients with AD may develop malperfusion syndromes which occur when blood flow is impaired due to expansion of the false lumen and collapse of the true lumen, causing end-organ ischemia.² This obstruction can be static or dynamic in nature and can affect all major vascular beds.⁴¹ Therefore, AD with malperfusion syndrome can present with stroke, spinal cord ischemia, paralysis, myocardial ischemia, mesenteric ischemia, renal failure, and/or limb ischemia that can be persistent or dynamic. One of the most dangerous complications of AD is dissection into the pericardial space, causing hemopericardium and potentially tamponade; AD is important to recognize as a potential cause of pericardial effusion, as acute and rapid drainage can result in hemodynamic collapse.⁴² If salvage pericardiocentesis must be performed for emergent stabilization prior to definitive operative management for Type A AD due to shock from cardiac tamponade, it should be done in a careful and controlled manner, withdrawing only 5 to 10 mL at a time and maintaining a systolic blood pressure of 80 to 90 mm Hg (ie, permissive hypotension).⁴³

Preliminary basic diagnostic studies in AD frequently yield nonspecific findings and are likewise insufficient to exclude AD except in patients with low pretest probability and a clear alternative diagnosis. Chest roentgenography may show a widened mediastinum, abnormal cardiac or aortic contour, pleural effusions, or a calcified aorta (rarely with evidence of aortic wall calcium displacement). Electrocardiography may show non-specific ST-segment or T-wave abnormalities, left ventricular hypertrophy, myocardial ischemia, or myocardial infarction with or without Q-waves. However, a significant number of patients may have a normal chest film and electrocardiogram (ECG), making these screening tests alone insufficient to rule out AD. Rarely, dissection of the aortic root involving the coronary ostia can result in localized ST-segment elevation on ECG in a coronary distribution, more often involving the right coronary artery with inferior ST-segment elevation.^{40,44,45} Notably, the incidence of this rare complication of an uncommon condition is dramatically less frequent than typical ST-elevation myocardial infarction, and patients with ST-elevation myocardial infarction are very unlikely to have AD as the underlying cause in the absence of a predisposing condition. Indeed, the index of suspicion for AD should be low in patients with ST-elevation myocardial infarction unless objective evidence suggesting AD is present (eg, malperfusion), even with severe chest pain radiating to the back.

IMHs and PAUs have similar pain presentations to classic AD. IMHs and PAUs often present with sudden onset, severe chest or back pain that can be migratory in nature.²⁸ PAUs often are asymptomatic and are incidentally detected. Physical examination findings are even rarer in IMHs and PAUs than in AD as IMHs and PAUs less frequently develop aortic insufficiency, pulse deficits, or ischemic limbs. Likewise, patients with IMHs are even less likely to have abnormalities on chest roentgenography or electrocardiogram than those presenting with AD.

BTTAI is even more challenging to detect as patients with severe polytrauma often present with altered mental status, obtundation, or other distracting injuries.³⁷ The presence of injuries to the chest wall (eg, sternal fractures, rib fractures, scapular fractures, pneumothoraces, hemothoraces), lung parenchyma (pulmonary contusion), tracheobronchial tree, diaphragm, or esophagus should raise concern for BTTAI. Patients with BTTAI may sometimes present with upper extremity hypertension which occurs due to the development of pseudo-coarctation physiology from an evolving dissection flap at the aortic isthmus, as can occasionally occur with traditional

AD. However, this phenomenon is rare as many of these patients present in shock due to hemorrhage or other injury. Chest roentgenography and focused ultrasonography in trauma (focused assessment with sonography for trauma [FAST] examination) are frequently utilized as initial diagnostic modalities in the primary survey in polytrauma. Simple chest films may show widened mediastinum, loss of the aortopulmonary window, capping of the lung apices from blood products, large pleural effusions from evolving hemothoraces, shift of the mainstem bronchus and trachea, or widening of the paravertebral stripe. Likewise, FAST examination may show hemothoraces or pericardial effusions. However, findings on these diagnostic tests are neither sensitive nor specific for BTTAI and cross-sectional imaging is needed.

In patients where there is suspicion for AD, basic laboratory testing is important in evaluating for alternative etiologies of symptoms as well as

determining the presence and extent of end-organ dysfunction (**Table 1**).⁴ D-dimer, a degradation product of fibrin cross linking, is often elevated in AD, IMH, and PAU and is a sensitive marker (>95%) for the presence of AAS.^{46–48} A cutoff value of less than 500 ng/ml has been proposed to rule out AD within 6 hours of presentation.^{46,49} However, while low D-dimer may be sufficiently sensitive to rule out possible AD, it lacks sensitivity for chronic dissections or those with thrombosed false lumens, IMHs, or PAUs. D-dimer also lacks specificity for AAS and can be elevated in other pathologic conditions such as pulmonary embolism, deep vein thrombosis, or disseminated intravascular coagulation where there is increased turnover of cross-linked fibrin.^{3,50} A normal D-dimer should only be used to rule out AD in patients in whom there is low clinical suspicion and a clear alternative diagnosis.

Ultimately, definitive diagnosis requires an understanding of aortic anatomy and vascular physiology which includes a complete assessment of the aorta describing the vessel dimensions and concomitant pathology, shape and extent of the dissection flap if present, involvement of branch vessels, compromise of aortic valve, size of the IMH or PAU if present, effects on end-organs, and presence or absence of pericardial effusion or other bleeding (**Box 2**). This is best accomplished with imaging modalities which have high sensitivity and specificity for aortic pathology. Contrast-enhanced, ECG-gated computer tomography (CT) angiography has excellent sensitivity and specificity for the detection of aortic pathology and can be done rapidly making it the preferred diagnostic test for AAS under most circumstances. There are multiple characteristic imaging findings in AD which help distinguish the true from the false lumen. Generally, the true lumen is smaller than the false lumen. Due to slower flow and lower pressures in the false lumen, the convex face of the dissection flap faces toward the false lumen. Often, the lumen that extends more caudally is the true lumen. Despite these generalities, only visualization of the entry flap allows for true determination of the true and false lumens. Multiplanar reconstruction of CT imaging assists with assessment of branch vessel involvement and ECG-gating of CT imaging helps reduce pulsation artifact which may mimic an AD on ungated CT imaging (as is often performed to exclude pulmonary embolism). CT is also helpful in assessing for active hemorrhage or blood collections in the mediastinum, pleura, or pericardium, and for excluding aortic rupture. The “triple-rule out” CT scan can allow for rapid evaluation for the presence of aortic pathology, pulmonary embolism,

Table 1
Basic laboratory evaluation for aortic dissection

Laboratory Test:	Helpful in Screening for:
Hemoglobin	Blood loss, bleeding, anemia
White blood cell count	Infection, inflammation
C-reactive protein	Inflammatory response
Troponin I or T	Myocardial ischemia, myocardial infarction
D-dimer	Aortic dissection, pulmonary embolism, thrombosis
Creatinine	Renal failure (existing or developing)
Aspartate transaminase/Alanine aminotransferase	Liver ischemia/liver disease
Lactate	Bowel ischemia, metabolic disorder
Glucose	Diabetes mellitus
Blood gases	Metabolic disorder, oxygenation
PT/INR and PTT, platelet count	Bleeding diathesis

<https://doi.org/10.1093/eurheartj/ehu28> From Erbel R, Aboyans V, Boileau C, et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). *Eur Heart J*. Nov 1 2014;35(41):2873-926. doi:10.1093/eurheartj/ehu28.

Box 2**Imaging considerations in acute aortic syndromes****Aortic Dissection**

- Visualization of the intimal flap
- Extent of the disease according to the aortic anatomic segmentation
- Identification of the false and true lumens (if present)
- Location of entry and re-entry tears (if present)
- Identification of antegrade and/or retrograde aortic dissection
- Identification grading and mechanism of aortic valve regurgitations (if present)
- Involvement of side branch vessels
- Evidence of malperfusion (low flow or no flow)
- Evidence of organ injury (brain, myocardium, bowels, kidneys, etc.)
- Evidence of pericardial effusion and its severity
- Evidence and extent of pleural effusion
- Detection of peri-aortic bleeding
- Signs of mediastinal bleeding

Intramural hematoma

- Localization and extent of aortic wall thickening
- Co-existence of atheromatous disease (calcium shift)
- Presence of small intimal tears

Penetrating aortic ulcer

- Localization of the lesion (depth and length)
- Co-existence of intramural hematoma
- Involvement of the peri-aortic tissue and bleeding
- Thickness of the residual wall

In all cases

- Co-existence of other aortic lesions: aneurysms, plaques, signs of inflammatory disease, etc.

<https://doi.org/10.1093/eurheartj/ehu28> From Erbel R, Aboyans V, Boileau C, et al. 2014 ESC Guidelines on the diagnosis and treatment of aortic diseases: Document covering acute and chronic aortic diseases of the thoracic and abdominal aorta of the adult. The Task Force for the Diagnosis and Treatment of Aortic Diseases of the European Society of Cardiology (ESC). *Eur Heart J*. Nov 1 2014;35(41):2873-926. doi:10.1093/eurheartj/ehu28.

and coronary artery disease with a high negative predictive value in patients presenting with undifferentiated chest pain.^{51–53} However, this may not provide optimal aortic imaging when AD is the leading differential diagnosis. For pregnant women with a high index of suspicion for AD, CT imaging can be obtained as for other patients recognizing the high risk of maternal morbidity and mortality with delayed diagnosis and the relatively lower risk of fetal harm with exposure to ionizing radiation during the third trimester (when AD often occur). When there is a lower index of suspicion, the risk/benefit of CT versus alternative imaging tests (which have their own potential risks) should be carefully balanced via shared decision-making.

MRI angiography is also a highly sensitive imaging modality for detection of aortic pathology and allows for visualization of the vessel from the arch to the distal segment, especially when contrast enhancement is used.⁵⁴ MRI can effectively visualize the intimal flap in AD and evaluate for aortic regurgitation, pericardial effusion, and involvement of the carotid or proximal coronary vessels.^{54–57} However, because MRI cannot be performed as rapidly as a contrast-enhanced computed tomography (CT) scan due to more lengthy scanning time, it should be used with caution in those at risk of deterioration and is typically more appropriate for chronic aortic pathology in a non-emergency setting (particularly for serial imaging).

Ultrasonographic techniques can detect aortic pathology, although these can be notoriously operator-dependent and imaging-dependent. Transesophageal echocardiogram (TEE) has high sensitivity (>95%) in the detection of AAS.⁵⁴ Advantageously, TEE can be performed at bedside and does not expose patients to radiation or contrast agents, but has the disadvantage of requiring personnel and conscious sedation which can lead to logistic delays.⁵⁸ For patients who are considered too unstable for a CT scan (particularly those who are endotracheally intubated), TEE is preferred if it can be performed expeditiously. TEE also easily provides functional information on cardiac contractility and can detect pericardial effusion, cardiac tamponade, or new valvular regurgitation. Trans-thoracic echocardiogram (TTE) is not sensitive enough to detect AAS (78% sensitivity in Acute Type A dissection, 40% in Type B) and should not be used to exclude the disease; the presence of a dilated aortic root seen on TTE may increase suspicion for AD in patients with undifferentiated chest pain.^{54,58}

Historically, retrograde aortography was the prior gold standard for detection of AAS due to its

high sensitivity and specificity.⁴ While it does offer the advantage of allowing for assessment of the coronary arteries, the test has fallen out of use due to its invasive nature, time, and cost. However, this may be appropriate for a patient with apparent ST-elevation myocardial infarction when AD must be ruled out (as opposed to creating a potential delay by performing a CT scan).

COMMON PHENOTYPES OF ACUTE AORTIC SYNDROMES

Because AAS can present with heterogeneous signs, symptoms, and result on laboratory testing, prompt diagnosis and initial treatment can be challenging and is often delayed. Effectively diagnosing and managing AAS requires that clinicians first have a high index of suspicion. The authors propose that clinicians assess risk factors and comorbidities, take a focused history, and conduct a limited physical examination and group patients into 1 of 4 common phenotypes that then guide further diagnostic evaluation and treatment:

Phenotype 1: Classic Dissection. In patients presenting with clear signs and symptoms of AAS where the pre-test probability is judged to be high by the evaluating clinician, initiation of empiric treatment is reasonable as described later. These very high-risk patients endorse characteristic “tearing” or “ripping” chest pain and/or have classic physical examination features such as pulse discrepancy, the murmur of acute aortic insufficiency, or end-organ damage concerning for malperfusion, often with 1 or more risk factors. Here, aggressive upfront treatment is warranted prior to and during confirmatory diagnostic testing which typically is with CT angiography, with TEE preferred for unstable patients in whom CT is not feasible. In many cases, early consultation with a surgeon is appropriate.

Phenotype 2: The undifferentiated syndrome. AAS should be considered in patients presenting with acute chest, back, or abdominal pain; syncope; and/or signs and symptoms of malperfusion. Here, clinicians should consider the pre-test probability of AAS (vs other likely alternative diagnoses) as informed by patient risk factors and comorbidities, features of the pain, and high-risk examination features (**Box 3**). The Aortic Dissection Detection Risk Score (ADD-RS) is a highly sensitive and easily calculable score to help guide the workup of the undifferentiated patient with possible AD by providing an estimate of pre-test probability (**Fig. 3**).^{59,60} Here, in the absence of an alternative diagnosis, the presence of 1 or more of the high risk features listed in **Box 3** should prompt aggressive evaluation with expedited

Box 3

High-risk features for aortic dissection

1. High-risk conditions
 - Marfan syndrome
 - Family history of aortic disease (esp. dissection)
 - Known aortic valve disease
 - Recent Aortic manipulation
 - Known thoracic aortic aneurysm ± bicuspid aortic valve
2. High-risk chest pain features
 - Chest, back, or abdominal pain described as:
 - Abrupt onset
 - Severe intensity
 - Ripping or tearing
- 3 High-risk examination features
 - Evidence of perfusion deficit
 - Pulse deficit
 - Systolic BP differential
 - Focal neurologic deficit (in conjunction with pain)
 - Murmur of aortic insufficiency (new and with pain)
 - Hypotension or shock state

Adopted from Rogers AM, Hermann LK, Booher AM, et al. Sensitivity of the aortic dissection detection risk score, a novel guideline-based tool for identification of acute aortic dissection at initial presentation: results from the international registry of acute aortic dissection. *Circulation*. May 24 2011;123(20):2213-8. <https://doi.org/10.1161/CIRCULATIONAHA.110.988568>.

aortic imaging using CT angiography. A low ADD paired with a D-dimer less than 500 ng/mL is very effective in excluding AAS, but D-dimer should not be used when the ADD is not low.⁶¹ In the ADVISED registry, the false-negative rate of an ADD-RS ≤ 1 combined with a negative D-dimer was 0.3%, suggesting that this strategy might be highly efficacious in ruling out AAS—indeed, this false-negative rate is likely equivalent to a CT scan. For intermediate-risk patients in whom AD is one of multiple potential diagnoses, a “triple-rule-out” CT scan is an efficient way to make a diagnosis. In undifferentiated trauma patients, there must be high suspicion for BTTAI in those with injuries to the chest or with complaints of chest pain and dedicated CT aortic imaging should be obtained expeditiously.³⁷

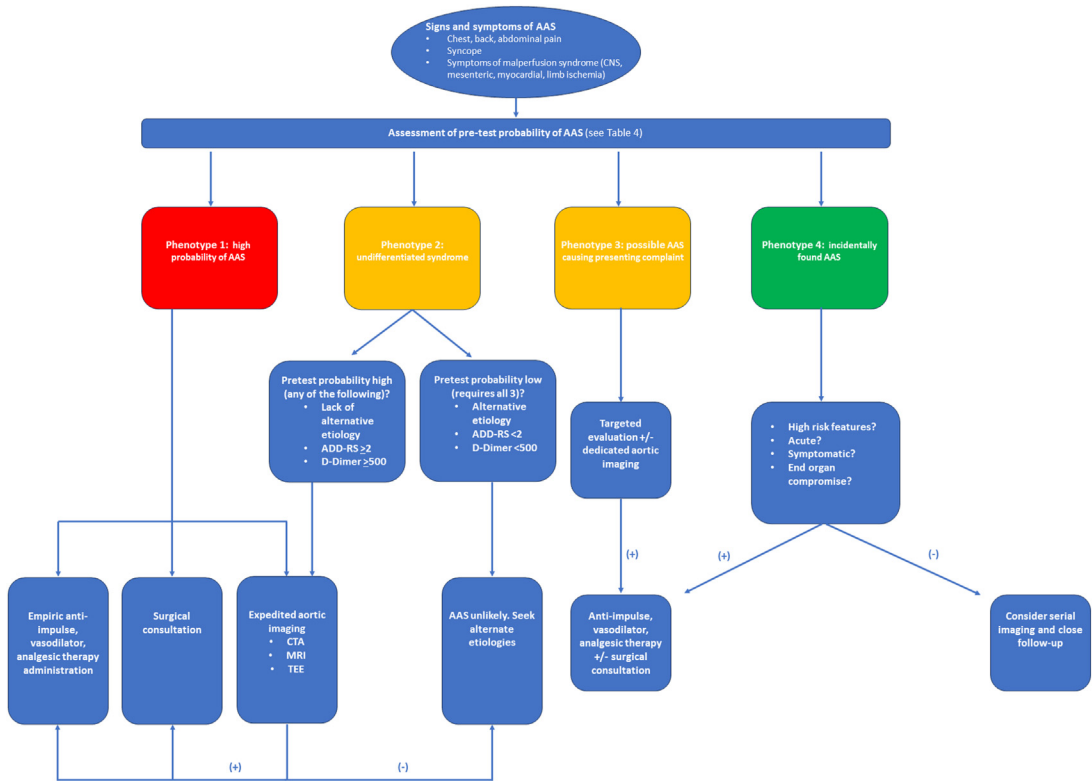


Fig. 3. Evaluation of acute aortic syndrome. Appropriate evaluation and management of acute aortic syndromes involve first considering the pre-test probability based on underlying risk factors and clinical presentation. Patients can then be grouped into 1 of 4 phenotypes with different diagnostic and management strategies.

Phenotype 3: AD as the cause of the presenting illness. Patients may present with non-thoracic conditions where AD is the proximate cause. Here, in the time-limited evaluation of presenting condition, it is important to remain cognizant that AD may be the upstream process responsible. As an example, in a patient presenting with new severe aortic regurgitation or a pericardial effusion, AD should be strongly considered (particularly if there is associated chest pain). Similarly, AD should be considered in patients presenting with mesenteric, limb, spinal cord, or even myocardial ischemia. The clinician must weigh the likelihood of AD being the precipitant of the presenting condition against the time, resources, and risks of further diagnostic testing. Again, expedited CT imaging is often justified.

Phenotype 4: incidentally discovered aortic pathology. In many cases, aortic pathology in the AAS spectrum may be incidentally discovered on cross-sectional imaging performed for some other indication; indeed, the increased use of advanced imaging could potentially be driving an increase in the apparent prevalence of aortic pathology. Here, where the clinical presentation is not due to aortic

disease and the patient may even be an asymptomatic outpatient, clinicians are challenged to determine if the aortic pathology is (1) acute or chronic, (2) causative or incidentally found, and (3) needs to be addressed promptly or can be deferred until a later time based on the symptomatology and evidence of vascular compromise or complications. A common example is an asymptomatic patient found to have interval development of AD on surveillance CT scan performed for a different indication.

MANAGEMENT

In all patients presenting with AAS, the initial therapy should be focused on reducing the transmural wall stress of the aorta while proceeding with evaluation for definitive management. The propagation of an evolving AD is dependent on the degree of intimal compromise as well as the rate of change in intraluminal pressure within the vessel from end diastole to systole (dP/dt).⁶² Therefore, initial medical therapy is focused on “impulse control” with immediate management focused on a combination of reduction in both the blood pressure and

Table 2
Intravenous antihypertensive pharmacotherapies in acute aortic syndrome

Medication	Bolus	Initial Infusion Rate	Infusion Titration Parameters	Max	Half Life	Notes
Beta-blockers (first-line therapies)						
Esmolol	500 mcg/kg q5min (up to 3 doses)	50 mcg/kg/min	Increase by 50 mcg/kg/min q5 min ×3 (with loading dose) then may increase by 50 mcg/kg/min q15 min thereafter	300 mcg/kg/min	2–5 min	Blood pressure-lowering effects delayed compared with heart rate-lowering effects Bolus and uptitrate infusion q5 min initially up to 3 times
Labetalol	20 mg, followed by 20–80 mg q10 min up to 300 mg total dose	1 mg/min	Increase by 0.5 mg/min q15 min	10 mg/min	3–8 h	Ratio of beta to alpha blocking activity is 7:1 Blood pressure effects greater and heart rate effects less than other listed beta-blockers
Metoprolol	5–10 mg (up to 0.15 mg/kg) initial dose and/or 5 mg q3-5 min for 3–4 doses	n/a	n/a	20–30 mg	3–4 h	More effective for lowering heart rate than blood pressure Higher doses can be used if not meeting heart rate or blood pressure goals, with diminishing returns seen
Vasodilators (add-on therapies)						
Sodium nitroprusside	n/a	0.5–1 mcg/kg/min	Increase by 0.5 mcg/kg/min	2–5 mcg/kg/min (up to 8–10 mcg/kg/min for short term)	2 min	Must monitor closely for cyanide and thiocyanate toxicity with prolonged use or high doses. Doses exceeding 5 mcg/kg/min should only be used for 10 min. Can elevate ICP, decrease cerebral blood flow, and reduce coronary blood flow (coronary steal)
<i>(continued on next page)</i>						

Table 2
(continued)

Medication	Bolus	Initial Infusion Rate	Infusion Titration Parameters	Max	Half Life	Notes
Nicardipine	n/a	5 mg/h	Increase by 2.5 mg/hq5min	15 mg/h	3–14 h	Delayed/prolonged effect; higher initial infusion rate (10 mg/h) can be used for up to 30 min as a loading dose Reduce dose to 2–5 mg/h once BP target is reached
Clevidipine	n/a	1–2 mg/hr	Double dose q2min. As BP approaches target, extend titration interval to 5–10 min.	21 mg/h (up to 32 mg/h for short term)	1 min	Delivered in lipid emulsion. Must check triglycerides and limit to 1000 mL maximum over 24 h
Nitroglycerin	n/a	20 mcg/min (up to 50 mcg/min)	Increase by 20 mcg/min (up to 50 mcg/min) q5min	200 mcg/min (up to 400 mcg/min for short term)	1–4 min	Tolerance (tachyphylaxis) develops over time Monitor for methemoglobinemia with prolonged or high-dose use
Non-dihydropyridine Calcium channel blockers (alternative first-line therapy)						
Diltiazem	0.25 mg/kg (up to 20 mg), may repeat 0.35 mg/kg (up to 25 mg) after 15 min	5 mg/h	Increase infusion by 2.5 mg/h q15 min	20 mg/h	3–7 h	Useful for bronchospastic airways disease as an alternative to beta-blocker (or for uncontrolled heart rate) Avoid in decompensated heart failure

heart rate to reduce dP/dt, although no high-quality evidence exists to guide selection of drugs (Table 2).

Beta-blockers reduce dP/dt and transmural wall stress through negative inotropic/chronotropic and antihypertensive effects; therefore, intravenous rapid-acting beta blockers such as esmolol, labetalol, or metoprolol are first line for the treatment of AD.^{2,4,63} This is true even in pregnancy and the post-partum states where the benefits of impulse control outweigh that of fetal growth restriction.² Esmolol is an ultrashort-acting intravenous beta-blocker which is often preferred due to its rapid onset, fast titration (with bolus dosing), and short duration of effect in the event of hemodynamic instability. Labetalol does not always provide maximal heart rate control despite its superior antihypertensive properties versus other intravenous beta-blockers. Patients will often continue to be hypertensive despite maximal beta blocker therapy and so frequently multiple agents are required for blood pressure control. Short-acting, rapidly titratable intravenous vasodilators such as sodium nitroprusside, clevidipine (preferred due to ease of use), or nicardipine can be used as adjuncts to beta-blockade, but should not be started before comprehensive beta-blockade due to reflex tachycardia from sympathetic activation that may increase dP/dt.^{2,64-66} Those patients intolerant to beta-blockers (or in whom beta-blockers fail to control the heart rate) can receive non-dihydropyridine calcium channel blockers (eg, diltiazem) for heart rate and blood pressure control.

Although consensus regarding hemodynamic goals does not exist, antihypertensive pharmacotherapies should be generally titrated to a heart rate below 70 beats per minute and a systolic blood pressure less than 120 mm Hg (or to the lowest blood pressure that maintains end-organ perfusion), often justifying placement of an arterial line in a limb without compromised perfusion.² Optimal heart rate and blood pressure targets have not been clearly defined in the setting of AAS, and the limb with the highest recorded blood pressure should generally be used for drug titration in patients with pulse deficits or between-limb blood pressure discrepancies. Sympathetic outflow secondary to pain can drive a tachycardiac and hypertensive response and so initiation of appropriate analgesic therapy, often with escalating doses of intravenous opiates, is critical as an early step in management (ie, before aggressive antihypertensive therapy is escalated).

Acute Stanford type A AD represents a surgical emergency and immediate surgical consultation is essential.^{2,25,40} The specific surgical techniques

are beyond the scope of this review and are tailored to the individual's anatomy and surgeon's expertise. In general, the surgical approach is to prevent extension of the dissection or rupture of the aorta with the specific surgery tailored to the extent of the vascular compromise, anatomy, the patient's signs and symptoms, and complications of vascular compromise the patient is manifesting to restore organ perfusion. Open repair is typical for patients with aortic arch involvement, while endovascular approaches (eg, TEVAR) may be appropriate when AD is isolated to the descending aorta. In pregnant patients, if Type A AD occurs within the first 26 weeks of gestation, emergency aortic surgery is recommended with fetal monitoring, recognizing the potential for fetal loss.² When the duration of pregnancy reaches the point where it is associated with high likelihood of independent fetal survival (especially after 28 weeks gestation), then emergency cesarean delivery followed by aortic surgery maximizes both maternal and fetal survival in acute Type A AD.²

In uncomplicated Stanford type B AD, medical management with impulse control, blood pressure management, and analgesia is the preferred treatment strategy.² However, in those patients who present with or develop complicated Type B AD (ie, with vascular compromise), surgical repair is indicated.² Similarly, surgical repair of uncomplicated Type B AD can be considered in situations of high-risk imaging or clinical features (Box 4).^{2,67-71} Here too, technique of the repair is informed by patient anatomy, signs and symptoms, and extent of the vascular compromise. After acute antihypertensive and anti-impulse therapy, transition to long-acting oral agents is appropriate to maintain adequate hemodynamic control without swings in blood pressure for patients in whom urgent surgical repair is not planned.

IMH and PAU are treated, for the most part, similarly to acute AD. Surgical repair should be undertaken in Type A IMH as well as Type B IMH complicated by high-risk features such as aortic rupture, end-organ malperfusion, periaortic hematoma, pericardial effusion with tamponade, and/or chest pain that is refractory or recurrent.² Expectant management is reasonable in uncomplicated Type B IMH as well as Type A IMH with prohibitively high operative mortality and absence of concerning features on imaging. PAUs are managed surgically if they are associated with IMH or aortic rupture.²

Initial management of BTTAI should consist of resuscitation and treatment of hemorrhagic shock with hypotension being allowed (permissive hypotension) to prevent propagation of the aortic injury. Like other AAS, impulse control is the preferred

Box 4**Features of type B dissection which would prompt surgical repair**

Complicated Type B dissection

- Aortic rupture
- Malperfusion from branch artery occlusion
- Extension of Type B dissection distally or proximally into ascending aorta (retrograde Type A)
- Progressive enlargement of true lumen, false lumen, or both during the acute phase
- Intractable pain
- Uncontrolled hypertension

High-risk clinical features of uncomplicated Type B dissection

- Hypertension refractory to greater than 3 different classes of antihypertensive agents at maximum tolerated doses
- Pain refractory to maximum tolerated doses of pain medications lasting greater than 12 hours
- Need for readmission

High-risk imaging features of uncomplicated Type B dissection

- Maximum aortic diameter greater than 40 mm
- False-lumen diameter greater than 20 to 22 mm
- Entry tear on lesser curvature
- Increase in total aortic diameter greater than 5 mm between serial imaging studies
- Bloody pleural effusion/hemothorax
- Imaging evidence of malperfusion

Adopted from Isselbacher EM, Preventza O, Hamilton Black J, 3rd, et al. 2022 ACC/AHA Guideline for the Diagnosis and Management of Aortic Disease: A Report of the American Heart Association/American College of Cardiology Joint Committee on Clinical Practice Guidelines. *Circulation*. Dec 13 2022;146(24):e334-e482. <https://doi.org/10.1161/CIR.0000000000001106>.

initial treatment strategy with short-acting intravenous beta-blockers and vasodilators being used to target systolic blood pressures less than 100 mm Hg and a heart rate of less than 100 beats per minute.³⁷ Grade I BTTAs are managed expectantly with medical therapy, unless they progress on serial imaging. Grades III and IV require operative intervention. Grade II BTTAs can be managed either surgically or with medical therapy and close follow-up.

Management of chronic AD is an evolving area with the increased incidental diagnosis of aortic pathology resulting from expanding use of cross-sectional imaging. In the absence of symptoms or end-organ complications, a non-urgent surgical approach is often appropriate, coupled with aggressive chronic antihypertensive therapy.^{2,4} Of note, even with a conservative strategy of “watchful waiting” in patients with a chronic Type A AD below the surgical threshold for intervention (55 mm), the risk of adverse aortic events remains high and increases over time.⁷² In cases where the precise timing is unclear but some chronicity is present, expectant management with acute antihypertensive therapy and serial imaging may be appropriate in the absence of complications, with a transition to chronic therapy if no change over time is observed on imaging.

REGIONALIZATION OF CARE

The effective diagnosis and management of AAS often requires multispecialty expertise. While many patients can be effectively managed at the center where they initially present, it is important to recognize that some patients may benefit from expeditious transfer to centers with expertise in managing AAS. This is particularly true for those patients who may need surgery, recognizing that specialty centers with extensive experience managing aortic disease are better equipped to handle the complexity of these cases.⁷³ Regionalized “Hub and Spoke” networks of care allow for the quick transfer of patients with AAS from sites of initial diagnosis to tertiary or quaternary cardiac intensive care units at high-volume aortic centers.⁷⁴ Even in acute Type A AD, where time is precious, acute medical therapy and diagnosis followed by urgent transfer to a high-volume center with subspecialty expertise is safe and has been associated with reductions in operative mortality.⁷⁵

Smoothly and swiftly transitioning patients between facilities requires streamlined performance at multiple levels. First, there needs to be easy access to subspecialty centers without delay in accepting a patient due to bed or transport team availability. Second, frequent bi-directional communication between practitioners at referring centers and those at the receiving center is essential. Third, referring centers should be easily able to provide any imaging or laboratory data that were obtained so that receiving centers do not need to duplicate these studies. Cloud networks can be helpful in data sharing and allow experts at the receiving facilities to review the data while the patient is actively being transported and thereby start formulating a treatment plan.⁷⁶ Fourth, a

cardiovascular expert at the subspecialty center should be immediately available and in frequent communication with the referral center and transport team. This clinician can mobilize resources at the receiving facility prior to patient arrival, particularly for patients who may need surgery. Lastly, transport teams should be agile with access to a variety of different types of transportation (ground, helicopter, fixed wing aircraft) to accommodate different weather conditions and move the patient as quickly and safely as possible. These teams should be able to initiate treatment and titrate therapies en route to the receiving facility with clear instructions on hemodynamic goals as often blood pressure and heart rate targets are not reached prior to transport.⁷⁷

The authors suggest that when Phenotype 1 patients, where the pretest probability of AAS is high, present to resource-limited facilities, empiric antihypertensive treatment should be initiated and the subspecialty center should be immediately contacted for transfer. Further diagnostic workup can then be done in collaboration with guidance from the subspecialty teams at the accepting facility. This can be particularly challenging at centers who do not have advanced CT angiography capabilities, raising questions about whether a non-dedicated (ie, non-gated) CT scan should be done prior to transfer rather than a dedicated aortic CT angiogram after transfer; many hub centers favor the latter approach to avoid repeating contrast imaging and potential logistical delays. Close collaboration on further workup may help mitigate delays in transport while patient is undergoing imaging testing at the initial facility. Alternatively, if the receiving bed is not ready at the accepting facility, clinicians can discuss when workup can be done where the patient initially presented.

SUMMARY

AAS represent a spectrum of highly lethal diseases that include AD, IMH, PAU, and BTTAI. It is important that clinicians remain vigilant and maintain a high index of suspicion as these diseases often present with non-specific signs and symptoms. To effectively diagnose and treat AAS, clinicians should undertake a prompt targeted evaluation which is informed by pre-test probability and patient risk factors. Clinicians should consider clinical factors which are associated with vascular abnormalities or increase wall stress as well as the characteristics of the presenting pain. It is crucial to be wary of malperfusion syndromes and consider whether upstream AAS is the proximate cause of the presenting end-organ compromise even in patients without chest pain. In those with a high

pre-test probability of AAS, empiric antihypertensive treatment should be initiated before the diagnostic workup is complete (eg, intravenous beta-blockade prior to CT imaging). In patients with an undifferentiated clinical syndrome where AAS is possible, dedicated aortic imaging with CT (including a “triple-rule-out” scan”) can be useful to make the diagnosis. In patients with high-pretest probability or confirmed AAS, immediate treatment should be implemented with impulse control aimed at reducing blood pressure and heart rate. Short-acting, rapidly titratable beta-blockers are the mainstay of treatment; however, additional rapidly acting vasodilators may be required to achieve hemodynamic targets. Operative intervention should be informed by the location of the pathology as well as complications and extent of downstream injury, and early surgical consultation is essential. Emergent transfer to subspecialty aortic centers to undergo definitive management is feasible and safe but must be done expeditiously and with close collaboration between the transferring and receiving facility. It is only through clinical vigilance, rapid action, and close coordination across regions and specialties that the care of patients with AAS will improve.

CLINICS CARE POINTS

- AAs classically presents as ripping or tearing pain in the flank, chest, or back that is abrupt in onset and often migratory. However, presentation of this highly lethal syndrome can be variable and masquerade as other common conditions including stroke, syncope, heart failure, tamponade, spinal ischemia, myocardial infarction, mesenteric ischemia, renal failure, limb ischemia, valvular regurgitation, or other end organ hypoperfusion. Clinicians should be wary of ‘Chest pain plus’ syndromes which involve non-thoracic symptoms plus thoracic pain.
- Heritable conditions and nonheritable risk factors which increase transmural aortic wall stress can compromise vascular integrity and precipitate AAS. Clinicians should consider pre-existing risk factors and maintain a high index of suspicion for AAS.
- Survival worsens as time elapses in AAS and so prompt diagnosis is critical.
- D-Dimer is a sensitive marker for AAS. A cutoff of <500ng/ml has been proposed to rule out AD within 6 hours of presentation. It is not sufficiently sensitive to rule out chronic dissection, IMHs, or PAUs. Therefore, a normal D-Dimer should only be used to rule out

dissection when there is a low index of suspicion and clear alternative diagnosis.

- CTA, MRI, and TEE are all highly sensitive methods of diagnosing AAS.
- We propose that patients conceptually group patients into four different phenotypes to guide further diagnosis and treatment. In phenotype 1, Classic Aortic Dissection, aggressive immediate treatment is critical both prior to and during diagnostic testing. In phenotype 2, the undifferentiated syndrome, clinicians should maintain a high index of suspicion and use risk scores to guide workup. A low ADD score and D-Dimer <500ng/ml effectively excludes AAS. D-dimer should not be used when ADD is elevated. In Phenotype 3, where AAS is the possible proximate cause of the presenting illness, clinicians should maintain a high index of suspicion for AAS and engage in a targeted workup informed by risk factors and pre-test probability. In Phenotype 4, incidentally discovered aortic pathology, clinicians must determine the chronicity, likelihood that the aortic pathology is driving the initial presentation, and need for urgent versus later intervention.

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