

Review Article

Update on Cardiovascular Echo in Aortic Aneurysm and Dissection

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The majority of aortic aneurysms comorbid with atherosclerosis can be asymptomatic and are discovered incidentally on routine physical examination or on imaging studies for other indications. Transthoracic echocardiography is a basic modality to assess patients with coronary artery disease and can be used for the screening of aortic aneurysm. Acute aortic dissection is a highly lethal cardiovascular emergency and requires prompt recognition. Although cardiovascular echo has a suboptimal accuracy rate for detecting aortic dissection, it is noninvasive, readily available, and easy to use. Recently, the concept of point-of-care ultrasound (POCUS) refers to the use of portable ultrasound at the patient's bedside for diagnostic and therapeutic purposes. POCUS could become an important tool in the screening and primary diagnosis for acute aortic dissection. Transesophageal echocardiography (TEE) was established to detect aortic dissection and determine the therapy. However, the use of TEE has decreased with the progress of contrast-enhanced computed tomography. Currently, attention is paid to TEE in the monitoring for the operation of aortic dissection, the use on bedside, and in emergency room, and the precise evaluation of aortic dissection for the patient with a history of allergy of contrast media and/or renal disturbance.


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Introduction

Aortic aneurysm and dissection are the principal diseases of the aorta. However, a greater part of aortic aneurysm is

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silent, while the rupture of the aortic aneurysm can cause uncontrolled hemorrhage and rapid circulatory collapse. The presentations of acute aortic dissection are myriad and mimic a wide array of other diseases while acute aortic dissection is an emergent life-threatening situation. Cardiovascular echo is noninvasive, readily available, and easy to use, and the concept of point-of-care ultrasound (POCUS) refers to the use of portable ultrasound at the patient's bedside or emergency room for diagnostic and therapeutic purposes. This review focused on the role of cardiovascular echo as a diagnostic image modality for aortic aneurysm and dissection.

Aortic Echo

A conventional, parasternal, left ventricular long-axis view could show an aortic root. The approach from the superior intercostal space can visualize the proximal to mid-portion of the ascending aorta (superior intercostal view). The descending aorta can be seen behind the left atrium in the parasternal view of echocardiography by adjusting the window depth (small-scale view). Abdominal aorta can be seen from subxiphoid and abdominal approaches (subxiphoid view). Aortic arch to proximal descending aorta can be illuminated from the suprasternal approach on the “sniff” and supine positions (suprasternal view). These approaches may be recalled as the “four Ss.”¹⁾ The routine evaluation of the aorta in echocardiography must make the time required for aortic echo shorter. Quick aortic echo using the four Ss approach will be able to play an important role not only in the search for aortic aneurysm, but also in the evaluation of acute aortic dissection in the emergency room.

Aortic Aneurysm

True aneurysm

A true aneurysm results in a localized dilation of the aorta involving all three layers (intima, media, and adventitia) of the arterial wall and can be classified as fusiform and saccular based on its shape.

Fusiform aneurysms, the more common type, are symmetrically dilated with the involvement of the entire

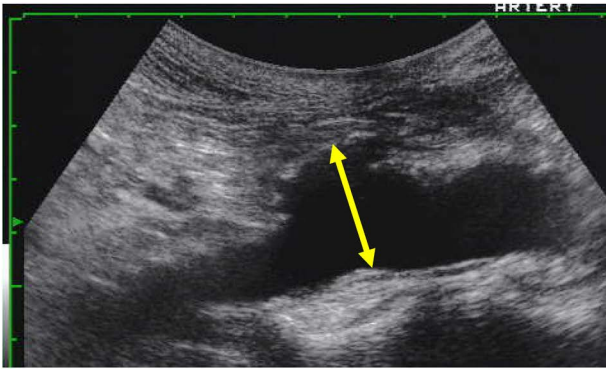


Fig. 1 The long-axis view of a saccular aneurysm showing a focal outpouching of the abdominal aorta and the maximum diameter is measured (arrow).

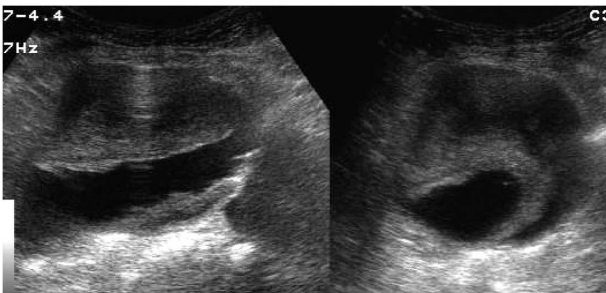


Fig. 2 Left: The long-axis view of the abdominal aorta showing a fusiform aortic aneurysm with mural thrombi. Right: Hemolysis is observed in the portion contacting on the aortic wall, which presents anechoic and crescent feature.

aortic circumference. Saccular aneurysms exhibit a focal outpouching.

Aortic echo is used to screen unruptured aneurysms and to examine the size of the aneurysm. Maximum minor-axis diameter in the short-axis view of fusiform aneurysms and the maximum diameter in the long-axis view of saccular aneurysm (Fig. 1) are together considered as the diameter of aortic aneurysm.

Aortic aneurysms can often be complicated by mural thrombi inside and inflammatory fibrosis outside. Mural thrombi might occasionally cause complicated hemolysis in the portion contacting on the aortic wall, which presents anechoic and crescent features (Fig. 2). This is called as “AC (anechoic crescent) sign.” The inflammatory fibrosis surrounding the aortic aneurysm (Fig. 3) can be observed as a similar configuration to the mantle of the earth, which is called as “mantle sign.”

When aortic aneurysms rupture, one can observe three kinds of high echoic effusion—pericardial effusion due to the rupture of ascending aortic aneurysm, pleural effusion due to the rupture of arch to descending aortic aneurysm, and retroperitoneal effusion due to the rupture of abdominal aortic aneurysm.

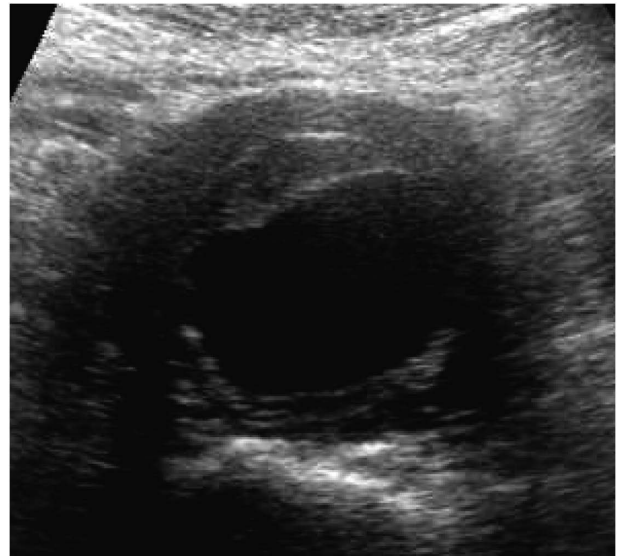


Fig. 3 Short-axis two-dimensional image of an inflammatory abdominal aortic aneurysm visualizes echoic fibrosis surrounding the aortic aneurysm.

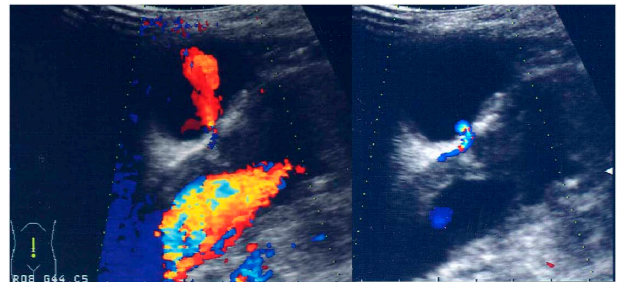


Fig. 4 Long-axis color Doppler image of a false aortic aneurysm showing a “to flow” (left) and a “fro flow” (right).

False aneurysm

A false aneurysm, or pseudoaneurysm, is a collection of flowing blood that communicates with the arterial lumen but is not essentially enclosed by the normal vessel wall; it is contained only by the adventitia or surrounding soft tissue. Pseudoaneurysms can arise from a defect in the arterial wall or a leaking anastomosis after aortic aneurysm repair. The blood flow through the defect of the aortic wall can be observed from the to-and-fro signal in color and pulsed Doppler echo (Fig. 4).

Aortic Dissection

Overt aortic dissection

In classic sense, acute aortic dissection required a tear of the aortic intima. Blood passes through the tear separating the intima from the media or adventitia, resulting in the so-called overt aortic dissection.

If a dissected ascending aorta ruptures even temporarily, it results in cardiac tamponade. Transthoracic echocar-

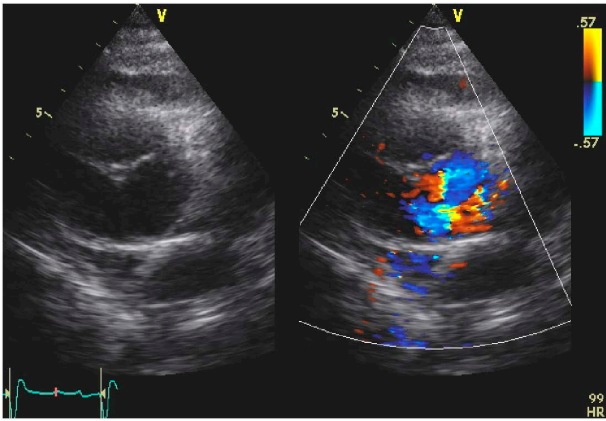


Fig. 5 Left: Short-axis two-dimensional image of the aorta in a recurrent case with overt aortic dissection showing three lumina in the aorta, which may resemble the Mercedes Benz symbol. Right: Short-axis color Doppler image of that showing a color Doppler signal in the true lumen.

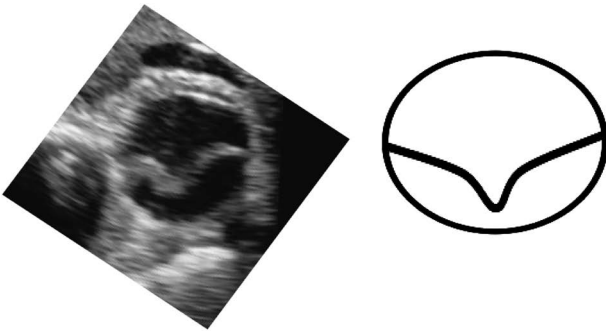


Fig. 6 Left: Short-axis two-dimensional image of an overt aortic dissection showing a flap in the aorta. Right: The schematic image may resemble the symbol of Mazda car company. Reproduced and partially modified from Reference 4 with permission.

diography (TTE) can easily disclose pericardial effusion, which is a frequent complication of type A aortic dissection, occurring in 19% of patients as per an international registry.²⁾

A flap in the aorta is an important finding, suggesting overt aortic dissection. Blaivas et al. reported on an ultrasonographic sign of dissection of the ascending aorta in the subxiphoid view that looked like a Mercedes Benz symbol.³⁾ Although this was the combinational form of a flap and aortic valve, the redissection in patients with aortic dissection can occasionally present three lumina in the aorta, which may also resemble the Mercedes Benz symbol (Fig. 5). The two-dimensional short-axis view of the primary dissected aorta with a flap may look like the Mazda symbol (Fig. 6). Consequently, I would like to propose that the Mazda symbol represents the primary dissected aorta with a flap and that the Mercedes Benz symbol

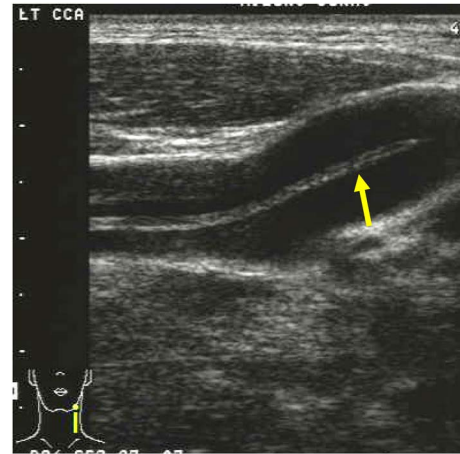


Fig. 7 Long-axis two-dimensional image of the carotid artery showing a flap on the inward side in a case with overt aortic dissection.

represents the redissected aorta with double false lumen.⁴⁾ Remembering these car company symbols could facilitate detecting aortic dissections using cardiovascular echo.

Aortic regurgitation can often be observed as a complication of type A dissection, occurs in 41%–76% of patients.⁵⁾ Echocardiography may show an eccentric color Doppler signal of aortic regurgitation due to aortic leaflet prolapse caused by the dissection flap propagating into the aortic leaflets. Non-coronary cusp might be involved more frequently than the other cusps. An extensive or circumferential dehiscing intimal flap prolapses into the left ventricular outflow tract during diastole, interfering with valve coaptation rarely.

Acute coronary syndrome related to the false lumen compressing the coronary ostium or the dissection flap involving the coronary artery complicates 1%–2% of patients with acute type A aortic dissection. It most frequently involves the right coronary artery, and echocardiography could visualize the ventricular wall motion abnormality.

Neurological manifestations occur in 17%–40% of patients with aortic dissection and are more common with type A dissections.⁶⁾ Neurologic ischemic stroke occurs in approximately 6% of patients with type A dissection. Vascular echo can apparently disclose the involvement of the common carotid artery (Fig. 7).

Aortic dissection may extend into the abdominal aorta and result in vascular complications and malperfusion. Renal artery involvement occurs in at least 5%–10% of patients and may lead to renal ischemia.⁷⁾ Mesenteric ischemia occurs in less than 5% of patients with aortic dissection and is associated with a marked increase in mortality. Abdominal ischemia comprises static and dynamic malperfusions. Vascular echo might show a flap extending the abdominal aortic branch (static malperfusion) or/and

a true lumen narrowing due to a false lumen expanding (dynamic malperfusion).

Aortic intramural hematoma

Aortic intramural hematoma is thought to be an atypical aortic dissection in which a hematoma develops in the medial layer of the aortic wall caused by the rupture of the vasa vasorum and the subsequent mural hemorrhage and/or a thrombosed false lumen.

Cardiovascular echo can demonstrate a circular or crescentic thickening in the aortic wall (Fig. 8). It could, however, be difficult to differentiate intramural hematoma

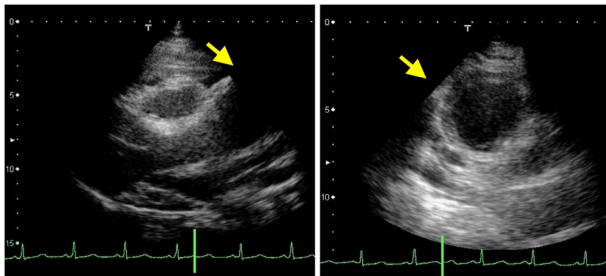


Fig. 8 Left: The parasternal long-axis view of the ascending aorta showing pericardial effusion and thickened aortic wall (arrow). Right: The parasternal short-axis view of the ascending aorta showing a crescent thickened aortic wall in a case with intramural hematoma.

from atheromatous plaques and mural thrombi in the aorta, although atheroma and thrombus might be characterized as high echo density protruding into the lumen of the aorta and a laminar mass localized in the aneurysm, respectively. The echocardiographic characteristics of intramural hematoma were reviewed for the differentiation from atheromatous plaques and mural thrombi in the aorta based on several textbooks and summarized them in Table 1.⁸⁾ Aortic intramural hematoma has been recognized to be relatively associated with aortic sclerosis compared to overt aortic dissection. The present findings suggest that intramural hematoma (smooth surface, crescent shape, echolucency, and extensive spread) could be recalled as sclerosis.

Although these characteristics presented here might not be absolute for discriminating intramural hematoma from atheromatous plaque and mural thrombi in the aorta, they provide knowledge on the evaluation of intramural hematoma using cardiovascular echo.

Penetrating atherosclerotic ulcer

In penetrating atherosclerotic ulcer, an atherosclerotic lesion penetrates through the internal elastic lamina into the media, often associated with a variable degree of intramural hematoma formation. Penetrating atherosclerotic ulcer is more common in elderly and is observed in the descending aorta than in the ascending aorta. Although

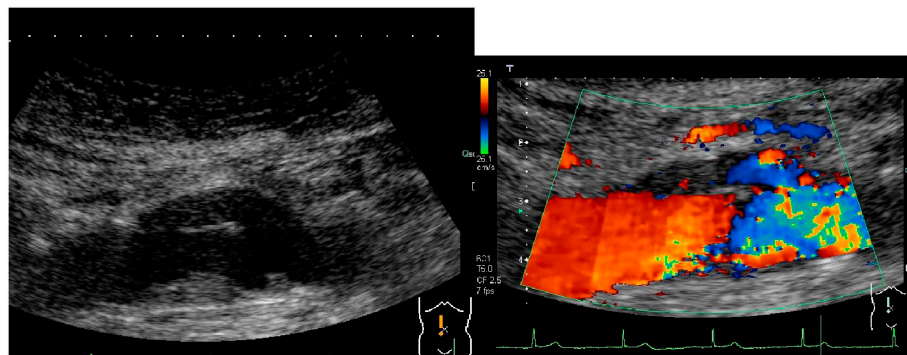


Fig. 9 Left: Long-axis two-dimensional image of a penetrating atherosclerotic ulcer showing a crater-like outpouching with atherosclerotic residual intimal flap. Right: Long-axis color Doppler image of a penetrating atherosclerotic ulcer showing a partial flow in the false lumen.

Table 1 Echocardiographic characteristics of intramural hematoma for the differentiation from atheromatous plaques and mural thrombi in the aorta

	Intramural hematoma	Mural thrombi	Atheromatous plaque
Surface	Smooth	Irregular	Undulating
Shape	Crescent or circular	Half-round	Cobblestone appearance
Lucency	Moderate	Laminar	High
Spread	Extensive	Localized in the aneurysm	Scattering

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penetrating atherosclerotic ulcer without intramural hematoma (Fig. 9) may be found incidentally on imaging studies,⁹⁾ penetrating atherosclerotic ulcer with intramural hematoma mostly represents acute chest or back pain, symptoms similar to classic aortic dissection.

The longitudinal view of the aorta in cardiovascular echo shows a crater-like outpouching with irregular edges occurring in the setting of heavy atherosclerosis.

POCUS for Patients with Chest Pain

A POCUS focused on effusion in the pericardial space, aortic abnormalities, size of the right ventricle (RV), shape of the left ventricle (LV), and asynergy of LV wall motion is presented.¹⁰⁾

Effusion in the pericardial space

Cardiac tamponade is a frequent complication of type A aortic dissection and may induce shock or hypotension. Although pericardial effusion could also be caused by pericarditis or ventricular rupture due to myocardial infarction, effusion in the pericardial space can be one of the most important echocardiographic findings that suggest aortic dissection.

Aortic abnormalities

Although aortic echo might not yet be established, the aorta should be tried to visualize during routine TTE with a four Ss approach. A flap in the aorta or a crescent shape of the aortic wall suggests aortic dissection. Dilation of the aorta can be a helpful finding suggesting acute aortic disease including the impending rupture of an aortic aneurysm.

The size of the right ventricle and the shape of the left ventricle

Pulmonary embolism is one of the emergent critical cardiovascular diseases, and there is all probability that this disorder might be missed in the emergency room. Echocardiography is a major modality to assess pulmonary embolism on the basis of an increase in the size of the RV. In pulmonary embolism, RV overload can cause displacement of the interventricular septum toward the LV, resulting in septal flattening and a D-shaped configuration of the LV cavity.

Asynergy of LV wall motion

Acute coronary syndrome is one of the most common causes of chest pain in the emergency room. Although electrocardiogram is the most reliable tool to diagnosing myocardial ischemia, asynergy of LV wall motion occurs earlier than electrocardiographic changes during acute ischemia.

The Exercise Assessment and Screening for You (EASY) tool as a POCUS for patients with chest pain

Although echocardiography is a user-dependent technology, point-of-care echocardiography can provide important immediate information in the emergency room and can be performed repeatedly if the patient's condition changes. Chest pain is one of the most common complaints in patients visiting the emergency room, which can reflect the presence of critical cardiovascular diseases. The present POCUS focuses on the assessment of effusion in the pericardial space, aortic abnormalities, the size and shape of the ventricles, asynergy of LV wall motion for the

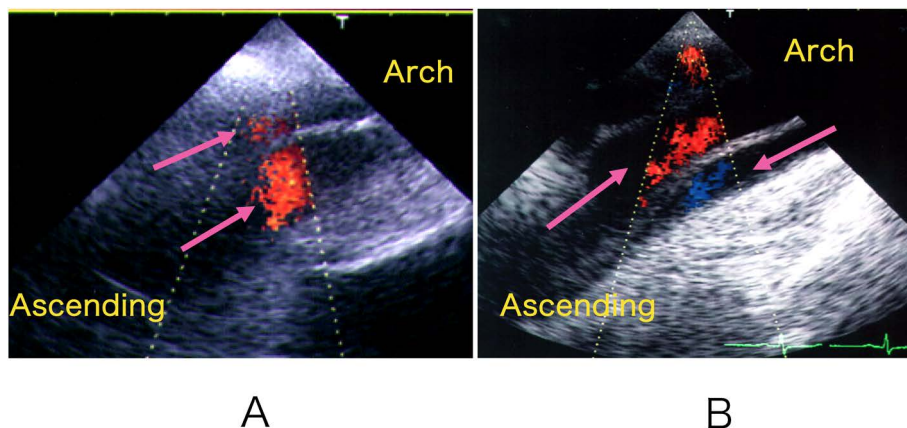


Fig. 10 **A:** The antegrade color Doppler flow signal in red in the false lumen between the ascending aorta and the aortic arch suggests an entry in the ascending aorta. **B:** The retrograde color Doppler flow signal in blue in the false lumen between the ascending aorta and the aortic arch suggests an entry in the aortic arch or descending aorta. Reproduced from Reference 11 with permission.

screening of aortic dissection, pulmonary embolism, and acute coronary syndrome. This protocol could be called EASY tool based on the beginning of the assessment items. Although it might not be easy to perform this application in all patients presenting with killer chest pain, routine EASY of these patients could play an important role in reducing the number of cases with a missed diagnosis of aortic dissection, pulmonary embolism, or acute coronary syndrome.

Role of Transesophageal Echocardiography

Transesophageal echocardiography (TEE) is highly accurate in the evaluation and diagnosis of acute aortic dissection (sensitivity, approximately 98%; specificity, 95%), but it is semi-invasive.⁷⁾ Currently, TEE can be applied to patients with allergy for a contrast medium or renal dysfunction and it can assist the surgical treatment for aortic dissection.

TEE may not completely visualize the distal ascending aorta and the proximal aortic arch, but it interrogates the remaining thoracic aortic segments well. TEE may visualize the intimal tear in 75%–100% of cases, differentiate the true and false lumen, and identify fenestrations in the intimal flap.⁷⁾ It was reported that adding the estimation of the primary entry site based on the flow direction in the false lumen (Fig. 10) made the sensitivity of TEE for the primary fenestration site higher.¹¹⁾

Features of the true lumen on TEE include a smaller lumen, systolic expansion, systolic antegrade flow, communication from the true to the false lumen in systole, and early and fast contrast-enhanced echocardiographic flow. TEE is 100% sensitive in detecting aortic regurgitation complicating dissection and may define its mechanism. TEE provides information about left ventricular function, proximal coronary arteries, and pericardial effusion and may assist with endovascular treatment.

Conclusion

Cardiovascular echo including aortic echo can provide progressive information on aortic aneurysm and dissection promptly and play an important role in the management of the aortic disease.

Disclosure Statement

The author has no conflict of interest.

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