The Role of Point-of-Care Ultrasound in the Emergency Department: The Case of a Contained Rupture of the Ascending Aorta Due to Type A Dissection Causing Subacute Cardiac Tamponade

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INTRODUCTION

Acute aortic syndrome (AAS), including aortic dissection, intramural hematoma, aortic ulcer, and painful thoracic aortic aneurysm, is relatively uncommon and is associated with considerable morbidity and mortality. Prompt recognition is crucial to improve survival. Computed tomographic (CT) angiography is the first-line investigation of choice, with high sensitivity and specificity for AAS. However, in real life there can be barriers to timely access to CT imaging. With the evolution of point-of-care ultrasound (POCUS) in the emergency department (ED) over the past decade, echocardiography has become an invaluable tool in the early diagnosis of AAS. We report the case of a patient with a history of chest pain a few days prior and episodes of syncope on admission. Timely POCUS in the ED, raising the suspicion for AAS (Stanford type A aortic dissection) complicated by subacute cardiac tamponade, proved to be lifesaving.

CASE PRESENTATION

A 49-year-old man was prealerted to the ED following recurrent collapse the night of his admission. He described having felt light-headed immediately before he collapsed but had no history of syncope. The patient described these events as a sequela to a few days' history of vague, nonradiating central chest pain and of feeling unwell, with somnolence, lethargy, and reduced appetite.

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The patient’s medical history included well-controlled hypertension on a single antihypertensive agent. He had no personal or family history of connective tissue disease. He had stopped smoking 7 years previously, consumed the equivalent of 15 to 20 units of alcohol per week, and denied any history of recreational drug use. He was employed as an airport maintenance engineer and upheld a modest degree of personal fitness.

His vital signs included a body temperature of 35.9°C, a heart rate of 106 beats/min, blood pressure of 91/63 mm Hg, a respiratory rate of 40 breaths/min, and oxygen saturation of 95% on room air. Pertinent physical examination findings included elevated jugular venous pressure and muffled heart sounds. His remaining clinical examination was unremarkable, including interarm blood pressure differential of <10 mm Hg. There were no features of Marfan syndrome.

A point-of-care blood test revealed normoglycemia and lactic acidosis with pH 7.209 and lactate 5.0 mmol/L (normal range, 0.5-2.2 mmol/L). Initial laboratory results demonstrated borderline normocytic anemia, a hemoglobin level of 129 g/L (normal range, 130-170 g/L), increased inflammatory markers (white cell count 15.6 × 10⁹/L, normal range, 3.7-11.1 × 10⁹/L) and C-reactive protein 39 mg/L (normal range, 0-6 mg/L), and acute kidney injury (creatinine 135 μmol/L, normal range, 64-104 μmol/L). He had an increased high-sensitivity cardiac troponin I level of 83 ng/L (normal range, <19.9 ng/L), and D-dimer of 2,706 ng/mL (normal range, <243 ng/mL). Chest radiography showed an enlarged, globular heart silhouette; coarsening of the bronchovascular markings; and no collapse or consolidation or pleural effusion or pulmonary edema (Figure 1A). Electrocardiography demonstrated sinus tachycardia with low QRS voltage in the standard leads and T-wave inversion involving leads I, aVL, and V4 to V6 (Figure 1B).

The patient was initially treated with intravenous fluids and antibiotics for possible infection; differential diagnosis for his chest pain included acute coronary syndrome, pericarditis, and pulmonary embolism. Cardiology opinion was requested to help in the diagnosis and guide ongoing management. Urgent POCUS was performed by a cardiology trainee using a portable bedside device with a fully capable ultrasound system available in the ED. The parasternal and apical images demonstrated a large pericardial effusion (>2 cm) with echo-dense floating structure best visualized in the subcostal modified views, in keeping with pericardial thrombus surrounding both the right and left heart chambers (Figures 2-4, Videos 1-5). There was a partial right atrial diastolic collapse (during right ventricular systole) and significant respiratory variation of both right and left ventricular inflow (E-wave) velocities, >25% and 40%, respectively, with plethora in the inferior vena cava >20 mm
nondilated aortic root (Figure 5, Video 1). The aortic valve was trileaflet, with no evidence of aortic regurgitation (Figure 2, Videos 2 and 6). Echocardiography identified an echogenic preformed thrombus (PE). Video 3:

**Video 1**: Echocardiographic images of the basal parasternal views of the heart modified to display the aortic root pathology. (A) Parasternal long-axis view showing the dissection flap (tear, yellow arrows) in the ascending aorta with the true lumen (TL) and false lumen (FL) and the pericardial effusion with echogenic preformed thrombus (PE). (B) Parasternal short-axis view showing the dissection in the ascending aorta with the TL and FL and the PE. Ao, Aorta; LA, left atrium; LV, left ventricle; PA, pulmonary artery; RA, right atrium; RV, right ventricle.

**Video 2**: Echocardiographic images of the parasternal short-axis (PSAX) view: basal view showing intact trileaflet aortic valve with partial diastolic collapse of the right atrium (RA) during right ventricular systole. Ao, Aorta; LA, left atrium; PE, pericardial effusion with echogenic preformed thrombus; PA, pulmonary artery; RV, right ventricle.

**Video 3**: Echocardiographic images of the modified apical four-chamber view (A4CV) to show the left ventricle (LV), left atrium (LA), right ventricle (RV), and right atrium (RA). There is a partial diastolic collapse of the RA during right ventricular systole, one of the signs of cardiac tamponade. Note the dense pericardial mass, in keeping with pericardial thrombus. PE, Pericardial effusion with echogenic preformed thrombus.

**Video 4**: Echocardiographic images of the apical views to show the motion of the left ventricle (LV), right ventricle (RV), and right atrium (RA). There is a diastolic collapse of the RA during right ventricular systole, one of the signs of cardiac tamponade. Note the dense pericardial mass, in keeping with thrombus. A2CV, Apical two-chamber view; A3CV, apical three-chamber view; A4CV, apical four-chamber view; LA, left atrium; PE, pericardial effusion with echogenic preformed thrombus.

**Video 5**: Echocardiographic images of the modified subcostal view of the right ventricle (RV), right atrium (RA), and pericardial space with a large amount of pericardial effusion with echogenic preformed thrombus (PE). LA, Left atrium; LV, left ventricle.

**Video 6**: Echocardiographic images of the apical three-chamber view (A3CV) with color Doppler shows no aortic regurgitation. LA, Left atrium; LV, left ventricle; PE, pericardial effusion with echogenic preformed thrombus; RA, right atrium; RV, right ventricle.

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(Figures 3 and 4). In addition, echocardiography identified an echogenic circular structure around the proximal ascending aorta above the sinotubular junction and a dissection flap more distally with a non-dilated aortic root (Figure 5, Video 1). The aortic valve was trileaflet, with no evidence of aortic regurgitation (Figure 2, Videos 2 and 6). Left ventricular systolic function was globally impaired, with maintained wall thickness and no regional wall motion abnormalities (Video 4). POCUS interpretation was that of a subacute ascending aortic dissection (Stanford type A), with evidence of hemodynamic compromise due to pericardial thrombotic effusion.

The POCUS findings amplified the need for urgent CT aortography. This subsequently confirmed an intramural hematoma in the proximal ascending aorta above the coronary ostia and an aortic dissection commencing at the mid ascending aorta involving the aortic arch and extending through the descending aorta into the abdominal aorta superior to the superior mesenteric artery (Figure 6). The distal ascending aorta and the aortic arch were aneurysmal, with a diameter of 41 mm. The dissection extended into the proximal celiac axis with normal enhancement noted in the downstream hepatic artery and splenic artery. In addition, a large, dense pericardial effusion was also described (>19 mm).

The medical team made arrangements for emergency transfer to a cardiothoracic center for urgent intervention. A few hours after his POCUS and CT diagnosis, the patient underwent an emergency operation. The intraoperative findings confirmed proximal ascending aortic dissection from above the right coronary ostium into the descending thoracic aorta. The aortic valve and the coronary arteries were spared, with a large pericardial effusion with an estimated 500-mL fresh clot anterior in the pericardium. A dissection tear in the distal ascending aorta and aortic arch was identified. As the intramural hematoma appeared to be organized, it gave the impression of a subacute dissection with acute decompensation due to hemopericardium due to a contained rupture around the posterolateral side...
of the ascending aorta. The ascending aorta was excised, the intramural hematoma evacuated, and a 28-mm Gelweave graft (Terumo) with a side arm was inserted. The patient made a good recovery and was discharged on postoperative day 7. Follow-up echocardiography demonstrated a well-seated aortic interposition graft with laminar flow in the repaired aortic arch.

DISCUSSION

It is well established that AAS, encompassing aortic dissection, aortic aneurysm, intramural hematoma, and symptomatic aortic ulcer, is a potentially life-threatening condition that warrants prompt recognition and treatment, especially when located in the ascending aorta and aortic arch.

AAS is uncommon, accounts for only 1 in 10,000 presentations to the ED, and is associated with high morbidity and an in-hospital mortality rate of 27.4%. Notably, type A aortic dissection is one of few diagnoses that has time-related mortality, with an immediate mortality rate of 1% to 2% per hour within the initial 24 hours of symptom onset. Acute cardiac tamponade as a result of aortic rupture is the most common fatal complication of type A aortic dissection, as presented in our previous clinical case. Early surgical intervention is the treatment of choice for type A aortic syndromes, irrespective of age, as highlighted in current guidelines, reducing the 1-month mortality rate from 90% to 30%.

Because of its rarity, AAS is underdiagnosed in the ED, resulting in missed cases or delayed diagnosis, with potentially catastrophic consequences. Severe sudden-onset chest pain, often described as a tearing sensation radiating to the neck or back, is common, reported by about 80% of patients with aortic dissection. However, AAS can mimic other conditions because of nonspecific presenting symptoms and often lacks classical features.

Baseline screening tests in the ED, such as biochemical markers, electrocardiography, and chest radiography, are nonspecific and can be unremarkable in the first few hours of symptom onset, making prompt recognition challenging. Findings on chest radiography can be normal except for mediastinal widening in up to 40% of patients with acute aortic dissection. Electrocardiography may misleadingly demonstrate features of an acute coronary syndrome if coronary ostia are involved. Low QRS voltages always raise suspicion for cardiac tamponade, especially in hemodynamically compromised patients with supporting clinical signs.

![Figure 2 Echocardiographic images of the parasternal views in diastole and systole.](image-url)
POCUS was introduced in the emergency setting by professional imaging societies approximately 12 years ago. Various studies have subsequently supported the use of POCUS in the diagnosis of thoracic pathology and have demonstrated that this imaging modality can reduce the length of stay in the ED and improve operational efficiency. It was designed to expedite diagnosis and facilitate triage and treatment decisions in the ED, without the need to perform a full echocardiographic acquisition. Detailed discussion of the training needs and of its limitations was reviewed in subsequent recommendations.

The principal role for POCUS is the time-sensitive assessment of symptomatic patients in the assessment of pericardial effusion and the evaluation of chamber size, global cardiac function, and patient volume status. In addition, POCUS is used to guide emergency invasive procedures, such as pericardiocentesis. In the critical care setting, POCUS provides a powerful adjunct to clinical examination for the assessment of patients presenting to the ED with chest pain, shortness of breath, and/or shock. The initial echocardiographic evaluation of chest pain should be directed to exclude alternative differential diagnoses such as acute coronary syndrome, pulmonary embolism, pericardial effusion, pneumothorax, and other pulmonary pathologies.

Early studies provided limited evidence for the use of transthoracic echocardiography in the diagnosis of AAS, but with the advancement of ultrasound technology and computing power, image quality has improved its diagnostic accuracy. Various studies have demonstrated that echocardiography can yield 90% to 98% sensitivity and 96% to 98% specificity for AAS involving the ascending aorta when assessing for direct and indirect sonographic features. Evidently, dissection flap and aortic root dilatation are both highly sensitive for aortic dissection. Reverberation and side-lobe artifacts during echocardiography can often mimic or sometimes obscure a dissection flap and hence result in both false-positive and false-negative detection of direct sonographic features of aortic dissection. Using multiple imaging planes and color flow Doppler imaging when evaluating the aorta may overcome these limitations. Nevertheless, in a recent study involving 127 patients with suspected aortic dissection, POCUS performed by

![Figure 3](image1.png)

**Figure 3** Echocardiographic images of the subcostal views of the heart chambers and the inferior vena cava (IVC). (A) IVC plethora with 22-mm diameter. (B) Subcostal views of the heart chambers in diastole. Note the pericardial effusion with echogenic preformed thrombus (PE). (C) Subcostal views of the heart chambers in systole. Note the PE and the “diastolic” collapse of the right atrium (RA) in right ventricular “systole.” Ao, Aorta; LA, left atrium; LV, left ventricle; RV, right ventricle.

![Figure 4](image2.png)

**Figure 4** Pulsed-wave (PW) Doppler spectral display and echocardiographic measurement of the E-wave velocity across the mitral (A) and tricuspid (B) valves demonstrate pathologic respiratory variation (arrows).
emergency physicians showed an impressive reduction of in-hospital and 30-day mortality compared with CT angiography alone, primarily because of the reduction in the time to diagnosis (10.5 and 79 min for POCUS and CT angiography, respectively). 14

The main limitation to the use of POCUS is the dependence on the investigator experience as a determinant of diagnostic accuracy. In addition, image quality may be degraded because of patient body habitus, pulmonary disease, or chest wall abnormalities. In current clinical practice, when there is clinical suspicion for AAS, in addition to POCUS, multimodality imaging with cross-sectional imaging should be performed.

In the case described, we hypothesize that our patient developed AAS several days before his presentation, manifesting as recurring chest pain and the slowly developing (subacute) pericardial effusion as a result of contained rupture of his ascending aorta, causing transient loss of consciousness before admission. One may argue that this was our patient’s survival mechanism, as acute aortic rupture and subsequent cardiac tamponade are the most common cause of sudden death. POCUS played a major part in identifying cardiac tamponade in support of clinical signs of hypotension, muffled heart sounds, and elevated jugular venous pressure (also known as Beck’s triad), as well as electrocardiographic features of low QRS voltages in the limb leads, with sinus tachycardia and chest radiography showing a globular heart silhouette. POCUS provided supporting echocardiographic signs of cardiac tamponade physiology showing a large effusion with thrombus in the pericardial space with right atrial diastolic collapse (during right ventricular systole), high respiratory variation of mitral valve and tricuspid valve inflow (E-wave) velocity (as a sign of the fixed cardiac volume limiting cardiac filling and ventricular interdependence), and inferior vena cava plethora. The detailed description of echocardiographic physiology caused by cardiac tamponade and its effect on the Doppler flow spectrum is eloquently summarized in the recent American Society of Echocardiography expert consensus statement. 15 POCUS described the ultimate cause as type A aortic dissection, which in turn facilitated urgent CT aortography our patient, confirming the extent of the dissection and resulting in an urgent cardiothoracic surgical referral that proved to be lifesaving.

**Figure 5** Echocardiographic images of the modified basal parasternal views of the heart to display the aortic root pathology. (A) Parasternal short-axis (PSAX) view: high basal view displaying the ascending aortic dissection with the false lumen (FL) and true lumen (TL). (B) Parasternal long-axis (PLAX) view: yellow arrows indicate the dissection flap (tear) in the ascending aorta. LA, Left atrium; LV, left ventricle; PA, pulmonary artery; PE, pericardial effusion with echogenic preformed thrombus; RV, right ventricle.

**Figure 6** Contrast-enhanced CT aortogram: axial views showing Stanford type A aortic dissection. The density of the tissue in the false lumen (FL) was 1.6 to 2 Hounsfield units (HU) and in the pericardium was 3 to 5 HU, suggesting blood density. (A) The ascending aorta (AscAo) intramural hematoma (IH) and descending aorta (DescAo) dissection with the false lumen (FL), true lumen (TL), dissection flap (blue arrows), and pericardial effusion (PE). (B) Dissection in the aortic arch (Ao Arch) with the dissection flap (blue arrows). PA, Pulmonary artery.
Surgical intervention for type A aortic dissection is usually open surgery, in the form of a supracoronary aortic graft, but depending on the extent of dilatation and/or involvement of the aortic root, it can also include aortic valve–sparing repair of the aortic root or aortic valve repair or replacement. In view of his complex Stanford type A aortic dissection, our patient underwent ascending aorta and hemiarch replacement. He made an excellent recovery, and follow-up echocardiography 4 months after surgery confirmed normal appearance of the ascending aorta and arch repair with laminar flow.

CONCLUSION

The application of POCUS in the ED is an invaluable resource that can expedite diagnosis and treatment for potentially life-threatening conditions such as AAS. As a bedside diagnostic test, echocardiography presents fewer contraindications than alternative imaging modalities. In our patient, POCUS helped diagnose AAS complicated by subacute cardiac tamponade due to contained ascending aorta rupture. Although the diagnostic accuracy of POCUS in AAS remains highly operator dependent, implementing multiple views and color flow Doppler imaging can enhance its accuracy. Expansion of the training curriculum in POCUS for emergency physicians has tremendous potential to make it a highly relevant diagnostic tool in patients presenting with AAS.

SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.case.2022.05.005.

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