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Typical but uncommon computed tomography angiographic appearance of left ventricular assist device: Awareness is key!

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ABSTRACT

Left ventricular assist devices (LVAD) are now a standard of care for patients awaiting heart transplant. Our patient had undergone placement of the HeartWare LVAD and presented to the hospital with complaints of fatigue, dyspnea, fever and discharge from the LVAD site. She underwent computed tomography angiography (CTA) to evaluate the LVAD. CTA revealed a hypodense area surrounding the outflow graft throughout its extent. This was suspicious of a thrombus. The repeat CTA performed 4 days later did not show any change in appearance of the outflow graft. This appearance was in fact due to the co-axial relationship of the two outflow grafts creating a potential space between them that can be filled with blood. This is a normal appearance and should not be mistaken for a thrombus. The awareness of the normal imaging appearance of the LVAD devices is essential to avoid unnecessary surgical intervention.

1. Introduction

Left ventricular assist devices (LVAD) are now a standard of care for patients awaiting heart transplant. LVAD devices can be complicated by thrombus, infection or mechanical dysfunction. Consequently, more patients will undergo imaging for evaluation of LVAD related complications. Thus, it is essential to be aware of the normal imaging appearance of these devices on CTA. We have highlighted the typical imaging appearance of the outflow graft of HeartWare assist device that may be confused with a thrombus. This is especially important in the emergency department setting where these patients will most often present. Radiologists need to be aware of the normal imaging appearance of these assist devices to give timely and accurate information to the requesting physician, and thus avoid raising a false alarm of a LVAD thrombus. This will avoid unnecessary surgical interventions and will expedite patient discharge as well.

2. Case presentation

A 15-year-old female presented to the outpatient department with complaints of increasing fatigue. She complained of becoming lightheaded and dyspneic after walking a short distance. She also reported low grade fever and diarrhea. She denied palpitations, edema, weight loss or gain, or chest pain. Her past medical history was significant for Marfan's syndrome, status post aortic root replacement (26 mm Gelwave graft) and aortic valve replacement (Trifecta 23 mm). During her previous admission she was listed for heart transplant status 1A due to worsening cardiac function. During that time, the decision was made to place a left ventricular assist device (LVAD) while awaiting the transplant. She underwent placement of HeartWare LVAD. Her prior medical history was complicated by multiple prior admissions with fever and fatigue due to Abiotrophia defectiva bacteremia. She previously completed 6-week course of intravenous antibitoics and had been on oral antibiotics at home. LVAD flows, power and rate were all stable. However, there was increase in discharge from the drive line site.

Laboratory work up revealed mildly elevated C-reactive protein (1.9) with no increase in white blood cell counts. Multiple blood cultures were negative. Due to concern for infection at the LVAD site and history of bacteremia, computed tomography (CT) with contrast was requested. Dual energy CT of the chest, abdomen and pelvis was performed. CT images demonstrated a homogenous fluid density area anterior to the LVAD conduit, however no adjacent fat stranding was seen (Fig. 1). Peripheral low-density material was seen surrounding the conduit from the LVAD device to the ascending aorta. (Fig. 2, Fig. 3 video 1 in Supplementary). The appearance and extent were suspicious of thrombus and thus the CT was repeated four days later. The repeat CT demonstrated a stable exam with no change in appearance of the

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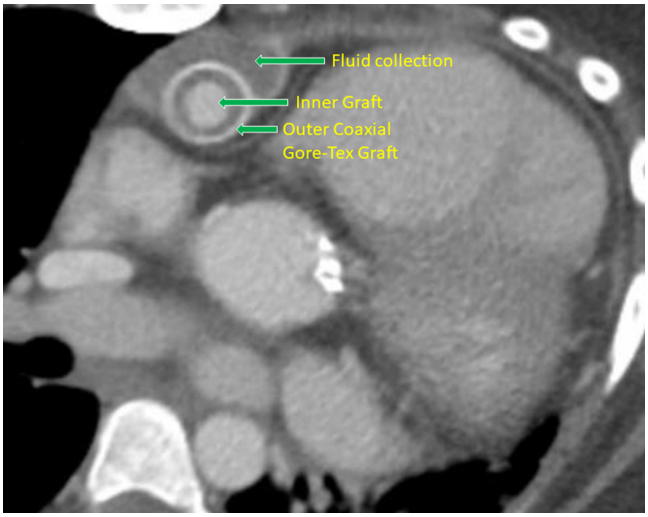

Fig. 1. Post-operative seroma formation.
Axial CT image shows fluid density collection anterior to LVAD conduit consistent with seroma.

conduit and no evidence of thrombus (Fig. 4). CT angiography was also repeated a month later with similar appearance of the outflow graft and of the fluid collection seen anterior to the graft. Ultrasound of the chest at the site of drainage showed a fluid collection with minimal echoes and not associated with wall thickening. The fluid collection was presumed to be seroma.

If unfamiliar with the CT appearance of an LVAD pump, imaging appearance may simulate presence of a thrombus in the outflow cannula. However, this appearance of the outflow cannula was due to the co-axial conduit morphology. The LVAD pump is connected to the polyester outflow cannula that connects to the ascending aorta. A strain relief is slid over the outflow graft (co-axial) to prevent kinking and securing the outflow graft to the pump (Fig. 5). This however creates a potential space between the two that may be filled with blood. This is because some amount of blood may seep into the potential space as the outflow grafts are partially permeable to passage of blood. This appearance should not be mistaken for a thrombus and is an expected post-surgical finding. Three-dimensional volume rendered reconstruction provides better understanding of make-up of these devices, particularly the co-axial arrangement of the outflow grafts (Fig. 2, video 1).

Patient was placed on broad spectrum intravenous antibiotics for a duration of 9 days. Patient remained clinically stable during her hospital course. LVAD was stable and working with adequate flow rate and she was discharged on suppressive oral antibiotics. After two months, she underwent heart transplant. The presumed seroma on computed tomography was sent for culture and was found to be sterile.

3. Discussion

Left ventricular assist devices are being increasingly used in the management of patients with chronic heart failure, serving as a stopgap until heart transplantation. Primarily, there are two different types of LVAD: those with pulsatile flow (these first-generation devices are no longer used due to issues with device stability); and newer continuous flow LVAD (Heart Mate II, Thoratec Corporation, Pleasanton, CA; Pleasanton, CA; HeartWare (Heart- Ware Inc., Framingham, MA) and HeartMate III (Thoratec Corporation, Pleasanton, CA). There are several advantages of continuous flow LVAD devices including lesser rate of device thrombosis, quiet mode of functioning; and reduced mortality rate [1]. With increasing use, many complications have also been encountered including device thrombosis, bleeding, infection and mechanical dysfunction. Imaging is often requested in patients with suspected complications. Computed tomography angiography (CTA) is often employed as a problem-solving tool in the evaluation of LVAD related complications. CTA provides excellent information regarding both the outflow and inflow cannulas [2]. The evaluation of device pump may also be improved by post-processing algorithms like Iterative Metal Artifact Reduction (IMAR) that reduces metallic artifacts. The use of Dual-energy CTA will provide an added advantage of reconstruction of mono-energetic data sets that can improve visualization of inflow cannulas and circulatory pump, especially at higher Kiloelectronvolt (KeV) energy [3]. However, it is also pertinent to be aware of the normal appearances of the LVAD on CTA to avoid misinterpretation.

4. HeartWare LVAD

To understand the normal CT anatomy, we need to be aware of the

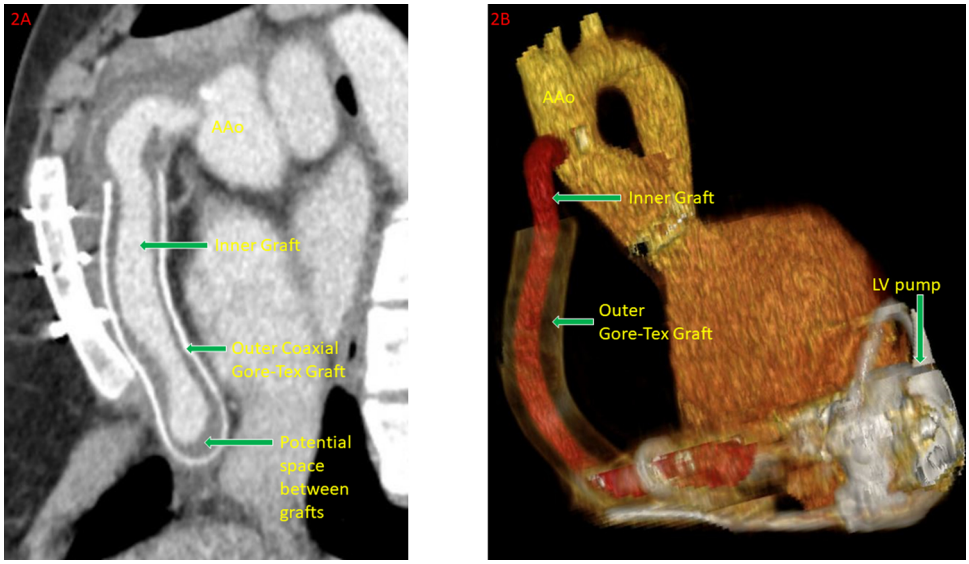

Fig. 2. CTA and Volume Rendered Images.
Multiplanar sagittal image (A) and Volume Rendered image (B) shows potential space in the outflow cannula created between inner polyester and outer Gore-Tex coaxial grafts. AAO: Ascending aorta; LV: Left ventricle

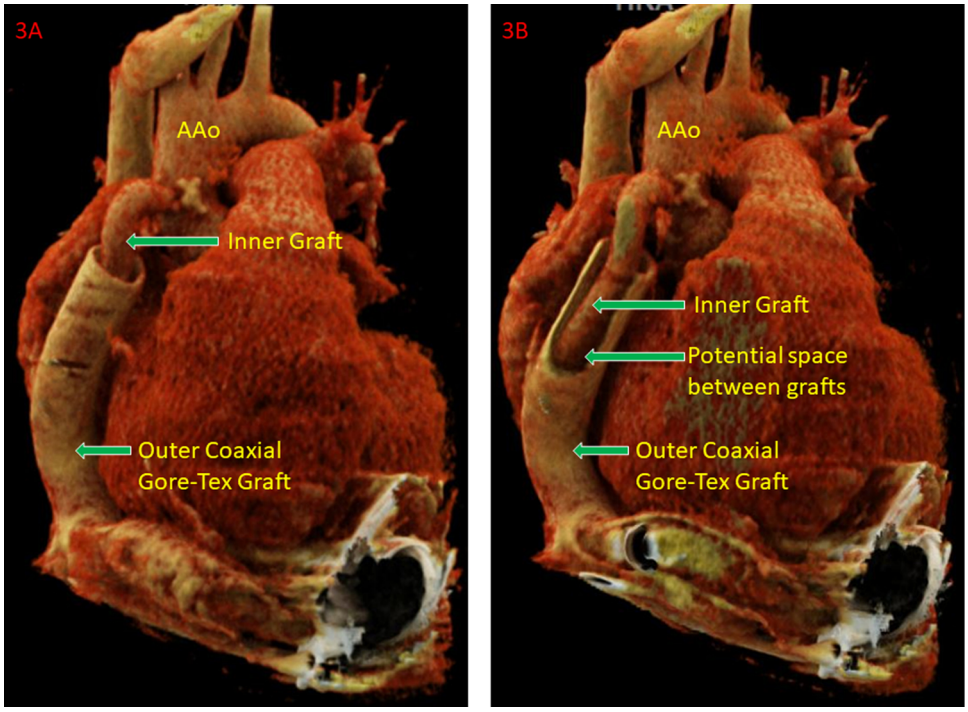

Fig. 3. Cinematic Volume rendered (VR) images.
Cinematic VR (A) and slab projection (B) images clearly show the relationship of inner and outer coaxial grafts with potential space between them.

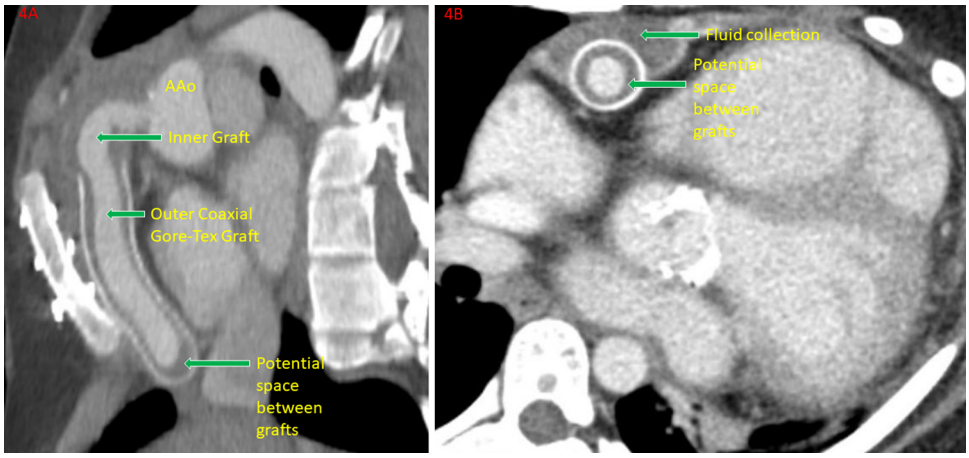

Fig. 4. Repeat CTA performed 4 days later.
Multiplanar sagittal (A) and axial (B) images show no change in appearance of outflow cannula and seroma.

Fig. 5. HeartWare assist device.
Graphical representation (5A, 5B) of the HeartWare left ventricular assist device and its parts

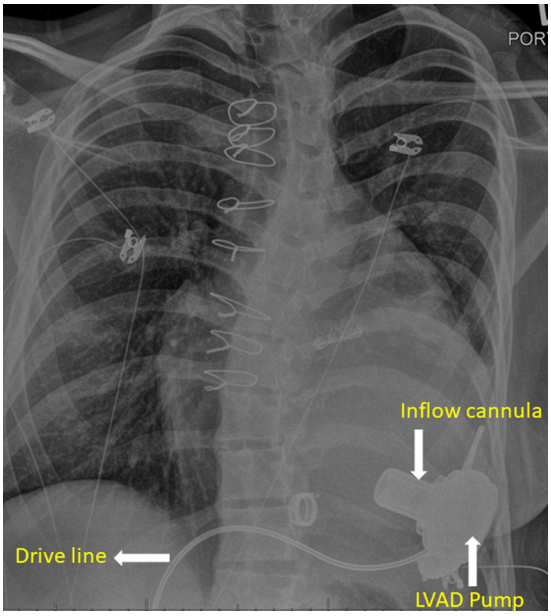

Fig. 6. X-ray chest showing LVAD placement.
Chest x-ray of the patient shows positioning of HeartWare LVAD in the pericardial space.

parts of HeartWare LVAD. It consists of circulatory pump with an integrated inflow cannula connected to the left ventricle, an outflow cannula with a strain relief connected to the ascending aorta, drive line, external controller and power sources. (Fig. 5, Fig. 6) The device is small enough to be implanted in the pericardial space. The Gore-Tex strain relief is co-axially advanced over the outflow cannula to prevent kinking.

5. Cause of apparent thrombus

The space between strain relief and outflow cannula creates a potential space that may become filled with blood as the outflow cannula is not all together impermeable to blood. This leads to appearance of apparent thrombus surrounding the outflow cannula on CTA [4]. However, this surrounding hypodensity is uniform throughout the extent of outflow cannula, unlike a thrombus that will be asymmetrical and focal. Similarly use of Gore-Tex patch and Teflon felts to prevent injury during surgery may appear as hyperattenuating material simulating calcification or hemorrhage [5]. Thus, in this subset of patients we should acquire either a non-contrast CT or reconstruct a virtual unenhanced CT data set from spectral dual energy CTA. This will help to characterize the surgical material used and avoid misdiagnosis.

Ethical statement

All procedures were in accordance with ethical standards for human experimentation and the Helsinki Declaration.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ejro.2019.03.004.

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