**Using aortic arch short axis views during transesophageal echocardiographic examination facilitates right ventricular assist device imaging**

**Short Title:** RVAD imaging with TEE

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**ABSTRACT**

Given the increased need for mechanical circulatory support and subsequent development of right ventricular assist devices (RVAD), appropriate imaging needs to be described to facilitate care in patients with cardiogenic shock and heart failure. We present three cases in which the upper esophageal aortic arch short axis (UE AA SAX) view on transesophageal echocardiography (TEE) was utilized to effectively image RVADs: to confirm normal positioning, to detect and guide repositioning, and to visualize malfunction. These cases support the importance of the UE AA SAX TEE view in RVAD outflow imaging and, when obtainable, should be included in routine RVAD assessment.

In recent years, there has been an increased utilization of percutaneous mechanical circulatory support (MCS) for the management of cardiogenic shock and end-stage heart failure.1 Percutaneous right ventricular assist device (RVAD) technologies have developed in response to this demand and are gaining more widespread use in right ventricular failure (RVF). RVADs require appropriate imaging to confirm correct positioning and ensure function. The proper imaging for this new technology has not been well described. The current literature emphasizes the importance of proper functioning, in the setting of known potential complications,2 and acknowledges the utility of transesophageal echocardiography (TEE)3; however, specific views have not been leveraged. We present three RVAD cases in which the upper esophageal (UE) aortic arch (AA) short-axis (SAX) view with TEE played an important role in management. Of note, International Review Board (IRB) waiver was obtained since this was a retrospective case study in which de-identifiable data was collected from patient records. Study consent was waived given the de-identifiable nature of this retrospective review. Procedure consent for TEE had been obtained in all cases.

The UE AA SAX view, a 60-90° view traversing the aortic arch, allows for effective visualization of the pulmonic valve and main pulmonary artery (Figure 1).4 Given that RVAD outflow cannulas are principally positioned in the main pulmonary artery proximal to its bifurcation,5 this view is valuable for RVAD assessment.

Case 1: Normal position

A 36-year old female with ischemic cardiomyopathy (CMP) developed subacute, severe RVF refractory to medical therapy seven days after orthotopic heart transplantation. An Impella RP (Abiomed Inc., Danvers, MA, USA) RVAD was implanted for recovery. The positioning of the Impella RP outflow was confirmed by TEE with UE AA SAX views (Figure 2).

Case 2. Device malposition

A 50-year old male with chronic, end-stage heart failure developed RVF after durable left ventricular assist device (LVAD) implantation necessitating extracorporeal RVAD with a TandemHeart (CardiacAssist, Pittsburg, PA, USA) pump and ProtekDuo cannula (CardiacAssist, Pittsburg, PA, USA). Four days after initial placement under fluoroscopy, ProtekDuo cannula malposition was noted on intra-operative TEE when the patient went to the operating room for chest closure. Under TEE UE AA SAX visualization, the cannula was carefully advanced such that the tip remained in the main pulmonary artery throughout the cardiac cycle, ensuring proper flow. Additional 3-dimesional images facilitated detailed position assessment (Figure 3).

Case 3. Device malfunction

A 61-year old female with a history of ischemic CMP developed RVF after LVAD implantation. A CentriMag (Thoratec Corporation, Pleasanton, CA, USA), extracorporeal RVAD, was implanted surgically as a bridge to recovery or transplantation. One month after RVAD implantation, acute RVAD flow reduction and significant hemolysis were observed. The UE AA SAX view demonstrated thrombus formation on the tip of the RVAD outflow cannula (Figure 4). The RVAD outflow cannula was exchanged surgically, and upon examination of the old cannula, the thrombus was noted to cause significant cannula exit obstruction.

These cases and corresponding images support the importance of the UE AA SAX TEE view in RVAD outflow imaging. When obtainable, this view should be included in routine RVAD assessment. This view is not meant to replace other commonly acquired views; rather, this is an effective, alternative way to image the right ventricular outflow tract, pulmonic valve, and pulmonary artery, particularly if other views cannot be acquired. While a transthoracic echocardiogram (TTE) parasternal SAX view may provide sufficient imaging, there are limitations with this view. TTE cannot be used for intra-operative assessment with an open chest, and in the early post-operative period, TTE views may be difficult or impossible to obtain due to wound dressings, chest tubes, and sternal pain. Deep gastric views offer visualization of the pulmonic valve and pulmonary artery, though the view may be challenging to obtain, and is contraindicated for use in patients with lower esophageal and gastric pathology. The UE AA SAX view is not contraindicated in these patients. Of note, additional biplane and 3-dimensional TEE views, including in the UE AA SAX view, facilitate improved positioning assessment.

**Author Contributions**

All the stated authors contributed in fundamental ways to the completion of this manuscript. All authors were involved in concept development or data collection, drafting or revision, and approval of this work.

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**FIGURE LEGENDS**

**Figure 1.** Upper esophageal aortic arch short axis (UE AA SAX) view with visualization of the pulmonic valve (PV), and main pulmonary artery (PA) in relationship to the aortic arch (AA). View simulated from exterior (Figure 1A), as a slice (Figure 1B), and as a representative TEE image via Virtual Transesophageal Echocardiography (Figure 1C).4

**Figure 2.** Impella RP outflow in the normal position in the main pulmonary artery (PA), distal to the pulmonic valve (PV).

**Figure 3.** A ProtekDuo cannula located just below the pulmonic valve (PV) in diastole (Figure 3A). The cannula passes into the main pulmonary artery (PA) in systole (Figure 3B). The cannula was advanced to the appropriate position in the PA (Figure 3C). Additional 3-dimensional views can better describe RVAD positioning with respect to surrounding anatomical structures (Figure 3D).

**Figure 4.** Thrombus at the tip of the pulmonary artery outflow cannula of a surgically placed Centrimag right ventricular assist device.