When Echocardiography Fails, Intravascular Ultrasound as an Alternative for Adequate Graft Patency in Hybrid Elephant Trunk Surgery

Fnu Thida1*, Tomas Carvajal2*, Shinya Unai3, Sergio E Bustamante3,4

1Anesthesiology Institute, Cleveland Clinic, 2Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic, 3Department of Cardiothoracic Anesthesia, Anesthesiology Institute, Cleveland Clinic, Cleveland, Ohio, 4Department of Anesthesiology, Mayo Clinic Health System, Minnesota, USA

*Both these two authors contributed equally, and claim first author co-authorship.

ABSTRACT
Aortic pathology is a common cardiovascular disease in the US. Transesophageal Echocardiogram is an invaluable imaging modality in the management of aortic pathology in perioperative setting. Intravascular ultrasound can assess coronary obstruction during coronary interventions and can be used in endovascular aneurysm repair. A 54-year-old male underwent Hybrid Elephant Trunk Surgery, for complex open aorta repair. There was functional confirmation graft patency via the femoral arterial line tracing, there was surgical confirmation via visual and physical inspection of graft, but there was lacking anatomical confirmation. Epiaortic ultrasound reassured the graft patency at level of the arch. However, transesophageal echocardiogram was not reassuring for adequate anatomical confirmation of patency. Intravascular ultrasound was used for anatomical confirmation of graft patency and position. This technology provides real time graft patency and is a great tool in open aorta reconstruction surgery.

Keywords: Aorta surgery, elephant trunk surgery, intravascular ultrasonography, transesophageal echocardiography

INTRODUCTION
Aortic pathology comprises a significant portion of cardiovascular disease in the US population. Aortic dissection and aneurysm of the aorta are significantly prevalent to about five cases per 100,000 inhabitants.1 Transesophageal echocardiogram (TEE) is an invaluable imaging modality in the management of aortic pathology in a perioperative setting.2 Intravascular ultrasound (IVUS) is a catheter-based technology that consists of a cylindrical ultrasonic transducer on the distal end, providing real-time images of blood vessels.3 It can be an alternative or complement to surface ultrasound to diagnose and guide the treatment of complex vascular pathology.3,4 Herein, we report the utilization of IVUS for anatomical confirmation of graft patency during an open aorta reconstruction case where TEE views were not adequate.

CASE PRESENTATION
A 54-year-old male with uncontrolled hypertension and poly-substance abuse presented with DeBakey Type-I acute aortic dissection and underwent emergent supracoronary
ascending aorta replacement with #28 Gelweave®
graft. Surgery was successful and he had no immediate
complications. The arch and descending dissection was
not repaired in this first stage. Unfortunately, he was
lost to follow-up and was readmitted 96 days later with
sudden onset of back pain and hypertensive emergency.
Imaging showed progressive dilation of the aortic arch
and descending aorta, requiring a hybrid elephant trunk
reconstruction of the aorta. He had a carotid subclavian
bypass a week before the open surgery.

The procedure was done under general anesthesia. Left
brachial and right femoral arterial lines were placed for
hemodynamic monitoring. The right axillary artery was
used for arterial cannulation. After redo sternotomy,
inferior vena cava (IVC) and superior vena cava (SVC)
were cannulated. Cardiopulmonary bypass was initiated
followed by deep hypothermic circulatory arrest with
antegrade cerebral perfusion. The arch was transected
between the innominate artery and the carotid artery.
The carotid artery was transected, the stump was over
sewed, and the subclavian artery was ligated. Through
the left femoral artery, a 34-mm Gore CTAG stent graft
was deployed, covering the orifice of the left carotid and
left subclavian artery. This Gore CTAG graft was utilized
as a frozen elephant trunk. The distal anastomosis was
then done, followed by innominate artery reconstruction
and reperfusion of the lower body. The carotid artery
reconstruction was done, followed by rewarming and
proximal Anastomosis to the surgical graft.

Graft patency was confirmed functionally with a
normal femoral artery line tracing. Surgical patency
was confirmed via a visual and physical inspection of
graft, but there was no anatomical confirmation of graft
patency particularly on the descending segments of
the aorta. Epiaortic echocardiographic view reassured
graft patency at the arch [Figure 1]. However,
TEE views [Figure 2] were not reassuring for adequate
anatomical confirmation of the descending aorta graft
patency. IVUS was utilized, entering the graft (at the
level of the distal arch) after a small 16 fr size incision
was done, the probe entered proximally and then it was
moved distally, to confirm and ensure the position and
patency of the elephant trunk graft [Figure 3]. The
patient had a complete recovery and was discharged
from the hospital on postoperative day 14.

DISCUSSION

IVUS can assess coronary obstruction during coronary
interventions[3] and can be used in endovascular aneurysm

![Figure 1: Epiaortic echocardiography using Multiplane and Color Flow
Doppler. Demonstrates systolic flow in the graft at the arch level and
presence of color artifact in the suture line and wall](image1)

![Figure 2: Transesophageal echocardiogram (TEE), the short axis of
the descending aorta and aortic graft, using Color Flow Doppler and
Multiplane. Demonstrates poor definition of flow within the graft material.
Inadequate demarcation of graft lumen and position of graft material
within the descending aorta. Poor visualization of anatomical structures](image2)

![Figure 3: Intravascular ultrasound (IVUS), placed intra graft in the
neo-descending aorta. Demonstrates adequate wall anatomy and
normal luminal/tubular structure within the elephant trunk graft while
moving IVUS probe distally](image3)
repair.\textsuperscript{[4,5]} There is no report of its use in open aortic surgery to confirm the patency of the aortic graft. TEE is routinely used intraoperatively for anatomical confirmation of aorta graft patency.\textsuperscript{[2]} However, when TEE views are not adequate, IVUS can be used for anatomical confirmation of graft patency. IVUS provides real-time graft patency and is a great tool in both open and hybrid aorta reconstruction surgery.

**Declaration of patient consent**
The authors certify that they have obtained all appropriate patient consent forms. In the form the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

**Financial support and sponsorship**
Nil.

**Conflicts of interest**
There are no conflicts of interest.

**REFERENCES**

1. Carpenter SW, Kodolitsch YV, Debus ES, Wipper S, Tsilimparis N, Larena-Avellaneda A, \textit{et al}. Acute aortic syndromes: Definition, prognosis and treatment options. \textit{J Cardiovasc Surg (Torino)} 2014;55:133-44.

2. Ciccone MM, Dentamaro I, Masi F, Carbonara S, Ricci G. Advances in the diagnosis of acute aortic syndromes: Role of imaging techniques. \textit{Vasc Med} 2016;21:239-50.

3. Elgendy IY, Mahmoud AN, Elgendy AY, Mintz GS. Intravascular ultrasound-guidance is associated with lower cardiovascular mortality and myocardial infarction for drug-eluting stent implantation: Insights from an updated meta-analysis of randomized trials. \textit{Circ J} 2019;83:1410-13.

4. Hoshina K, Kato M, Miyahara T, Mikuniya A, Ohtsubo N, Miyata T. A retrospective study of intravascular ultrasound use in patients undergoing endovascular aneurysm repair: Its usefulness and a description of the procedure. \textit{Eur J Vasc Endovasc Surg} 2010;40:559-63.

5. Pearce BJ, Jordan WD Jr. Using IVUS during EVAR and TEVAR: Improving patient outcomes. \textit{Semin Vasc Surg} 2009;22:172-80.