Acute TEVAR and the Additional Value of Intravascular Ultrasound

IVUS can provide critical information when other imaging has proven inconclusive or is unavailable.

BY JASPER W. VAN KEULEN, MD; JOHN ARUNY, MD; AND BART E. MUHS, MD, PHD

Intravascular ultrasound (IVUS) is an imaging technique wherein an ultrasound device is attached to a catheter, allowing images to be obtained from inside blood vessels. These images can be used as an adjunct to or as replacement of other imaging modalities in the diagnosis and treatment of cardiovascular disease.

One of the applications of IVUS in vascular surgery is during the process of the endovascular placement of a stent graft in the thoracic aorta. IVUS may especially be of benefit during the endovascular treatment of patients with a ruptured thoracic aortic aneurysm or with a traumatic rupture of the thoracic aorta. This article describes the potential advantages and disadvantages of IVUS in the endovascular treatment of patients with a ruptured thoracic aorta.

IVUS AND ACUTE TEVAR

IVUS provides reliable real-time diameter and length measurements of the aorta (Figure 1).[1] IVUS measurements closely agree with computed tomographic (CT) measurements, but IVUS images are in some cases even the reason to alter a stent graft selection initially based on CT measurements.[2] IVUS can therefore be of help in patients with indecisive CT angiography or magnetic resonance angiography and in patients without any other imaging.

Thoracic endovascular aneurysm repair (TEVAR) is shown to decrease the mortality rate of patients with ruptured aneurysms when compared with open repair.[3] The problem with TEVAR in the acute setting, however, is the preoperative need for cross-sectional images. The acquisition of CT angiography images, which are generally used, is time-consuming and requires patients to be transferred, thereby possibly reducing patients' survival rates. IVUS might thus be of great value in hemodynamically unstable patients with a ruptured thoracic aorta wherein no preoperative images have been acquired due to time restrictions. The decision to perform TEVAR or open repair can be made with the use of IVUS in the operating room with no additional patient transfers required.

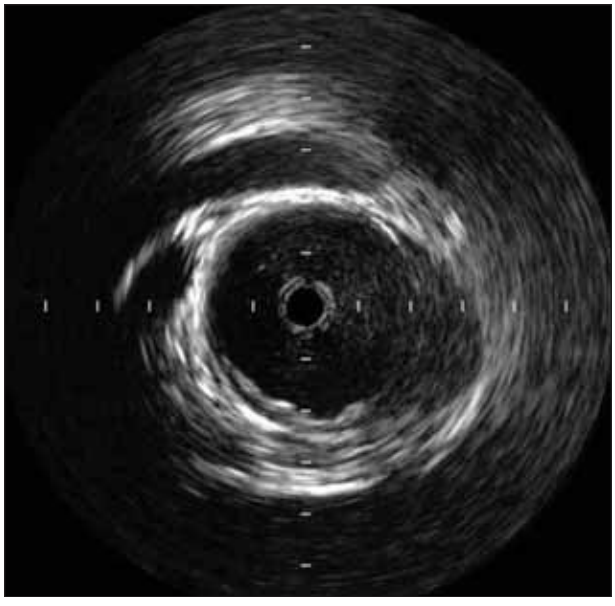


Figure 1. IVUS image of the aorta.

In addition, IVUS provides real-time images of the dynamic environment of the aorta, which is important,

(Courtesy of the Volcano Corporation Peripheral Atlas.)

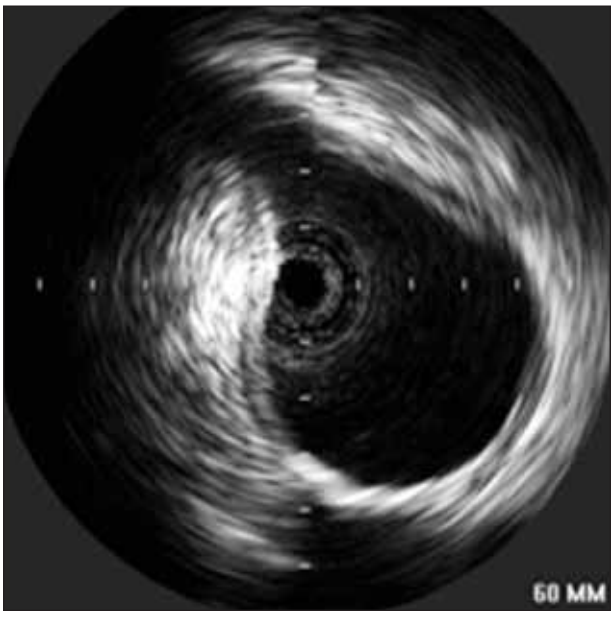
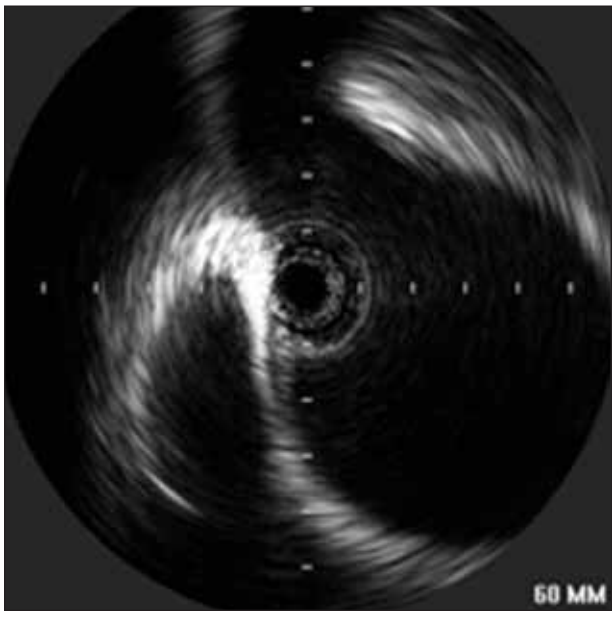


Figure 2. IVUS image of the left subclavian artery.



(Courtesy of the Volcano Corporation Peripheral Atlas.)

Figure 3. IVUS image of the innominate artery.

as the thoracic aorta is shown to expand significantly per heartbeat.[4,5] Diameter changes of the thoracic aorta during the cardiac cycle of more than 20% are common, and not taking these movements into account might lead to type I endoleaks or stent graft migration.[4] Moreover, it is also known that the diameter of the thoracic aorta decreases significantly during blood loss.[6] Images obtained before fluid resuscitation in patients with a ruptured thoracic aorta and severe blood loss may thus result in the measurement of aortic diameters that do not represent the fully resuscitated diameter values. With IVUS, images can be obtained before, during, and after fluid resuscitation. The use of IVUS might therefore lead to optimal stent graft sizing in patients with a ruptured thoracic aorta.

During the deployment of a thoracic stent graft, given the real-time images IVUS provides, the most optimal site for proximal and distal landing zones of the stent graft can be chosen. IVUS is able to clearly visualize the branches of the thoracic aorta and might help in preventing unintentional coverage of side branches and stent graft sealing and fixation-related problems (Figures 2 and 3). In addition, IVUS will aid in covering the smallest part of the aorta as possible in patients with an aortic rupture by identifying the exact site of transection.

Besides these specific advantages of IVUS for patients requiring acute TEVAR, there are some other general advantages of IVUS. First, the use of contrast agents is not required while performing IVUS; it currently is an attractive imaging alternative in patients with (minor) renal insufficiency or contrast allergy but might help in reducing the amount of contrast agent used in all EVAR or TEVAR patients. Second, the exposure to radiation is reduced if IVUS is used instead of angiography.[7] This can be of importance to all patients that are being treated by EVAR or TEVAR, as the radiation burden in these patients is already significant.[8] Third, IVUS is capable of providing information about the alignment of the stent graft to the aortic wall and the existence of endoleaks after the placement of a stent graft.[9] The use of IVUS might thereby make the periprocedural use of angiography unnecessary. In a study by von Segesser et al, it was shown that angiography could be replaced by IVUS while obtaining comparative EVAR results.[7]

"IVUS is able to clearly visualize the branches of the thoracic aorta and might help in preventing unintentional coverage of side branches and stent graft sealing and fixation-related problems."

There are certain cases wherein IVUS needs to be supported by angiographic images due to technical failure of the IVUS device. Another disadvantage of IVUS, besides a potential technical failure, is that it adds time to the endovascular procedures, although it generally is not more than 10 minutes. In addition, guidewires, introducer systems, and stent grafts can make the IVUS images less reliable. Finally, the interven-

tionist should be aware that the IVUS device should be perfectly perpendicular to the aorta while measuring the aortic sizes to prevent oblique measurements, which is of special importance while measuring in the aortic arch. The IVUS technique is still evolving, and new developments are being made. Newer IVUS technologies, such as forward-looking IVUS and optical coherence tomography, are awaited with interest and might further improve the technology.

Currently, IVUS is already capable of investigating whether patients are suitable for TEVAR. Moreover, it can be used for optimal stent graft sizing measurements and is of help in deploying a stent graft at the most optimal site. For these reasons, IVUS might be of great additional value to patients with a ruptured thoracic aorta. ■

Jasper W. van Keulen, MD, is with the Section of Vascular Surgery at Yale University School of Medicine in New Haven, Connecticut. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein. Dr. van Keulen may be reached at jasper.vankeulen@yale.edu.

John Aruny, MD, is with the Section of Interventional Radiology at Yale University School of Medicine in New Haven, Connecticut. He has disclosed that he holds no financial interest in any product or manufacturer mentioned herein.

Bart E. Muhs, MD, PhD, is with the Section of Vascular Surgery at Yale University School of Medicine in New Haven, Connecticut. He has disclosed that he is a paid consultant to Cook Medical, Medtronic, Inc., and W. L. Gore & Associates.

1. van Essen JA, Gussenhoven EJ, Blankensteijn JD, et al. Three-dimensional intravascular ultrasound assessment of abdominal aortic aneurysm necks. J Endovasc Ther. 2000; 7:380-388.
2. Garret HE, Jr., Abdullah AH, Hodgkiss TD, et al. Intravascular ultrasound aids in the performance of endovascular repair of abdominal aortic aneurysm. J Vasc Surg. 2003; 37:615-618.
3. Jonker FH, Giacovelli JK, Muhs BE, et al. Trends and outcomes of endovascular and open treatment for traumatic thoracic aortic injury. J Vasc Surg. 2010; 51:565-571.
4. Van Prehn J, Vincken KL, Muhs BE, et al. Toward endografting of the ascending aorta: Insight into dynamics using dynamic cine-CTA. J Endovasc Ther. 2007; 14:551-560.
5. van Keulen JW, van Prehn J, Prokop M, et al. Dynamics of the aorta before and after endovascular aneurysm repair: a systematic review. Eur J Vasc Endovasc Surg. 2009;38:586-596.
6. Jonker FH, Mojibian H, Schlosser FJ, et al. The impact of hypovolaemic shock on the aortic diameter in a porcine model. Eur J Vasc Endovasc Surg. 2010;40:564-571.
7. von Segesser LK, Marty B, Ruchat P, et al. Routine use of intravascular ultrasound for endovascular aneurysm repair: angiography is not necessary. Eur J Vasc Endovasc Surg. 2002;23:537-542.
8. Kalef-Ezra JA, Karavasilis S, Ziogas D, et al. Radiation burden of patients undergoing endovascular abdominal aortic aneurysm repair. J Vasc Surg. 2009;49:283-287.
9. Vogt KC, Brunkwall J, Malina M, et al. The use of intravascular ultrasound as control procedure for the deployment of endovascular stented grafts. Eur J Vasc Endovasc Surg. 1997;13:592-596.