The Heart Surgery Forum #2004-1130
7 (6), 2004 [Epub November 2004]
doi:10.1532/HSF98.20041130

Online address: www.hsforum.com/vol7/issue6/2004-1130.html

The Use of 3D Epiaortic Scanning to Enhance Evaluation of Atherosclerotic Plaque in the Ascending Aorta: A Case Series

Daniel T Bainbridge, MD, FRCPC,[1] John M. Murkin, MD, FRCPC,[1]
Alan Menkis, MD, FRCSC,[2] Bob Kiaii, MD, FRCSC[2]

[1]Department of Anesthesiology and Perioperative Medicine and [2]Division of Cardiac Surgery, London Health Sciences Center and The University of Western Ontario, London, Ontario, Canada

ABSTRACT

Transesophageal echocardiography (TEE) is becoming the standard of practice for cardiopulmonary bypass (CPB) surgery. Unfortunately, large sections of the ascending aorta are not visible on TEE, and epiaortic scanning has proven superior to TEE and aortic palpation in determining the extent of plaque in the ascending aorta. The recently introduced ×4 3-dimensional (3D) ultrasound probe allows both real time 3D imaging and gated acquisition sequences. We present a case series in which 3D ultrasound was used for epiaortic imaging in patients undergoing elective cardiac surgery, and we discuss the benefits and limitations of this imaging modality.

BACKGROUND

The use of transesophageal echocardiography (TEE) is becoming the standard of practice for cardiopulmonary bypass (CPB) surgery and is now a class IIa indication for the assessment of aortic atheroma [Cheitlin 2003]. Unfortunately, large sections of the ascending aorta are not visible on TEE because of the interposition of the right mainstem bronchus between the mid–ascending aorta and the esophagus. Epiaortic scanning has proved superior to TEE and aortic palpation in determining the extent of plaque in the ascending aorta [Konstadt 1995, Royse 1998, Wilson 2000]. Recent studies have also suggested that the incidence of stroke is reduced when epiaortic directed cannulation is employed to avoid atherosclerotic regions of the ascending aorta [Trehan 1997]. The recently introduced ×4 3-dimensional (3D) ultrasound probe (Philips Medical Systems, Andover, MD, USA) allows both real time 3D imaging and gated acquisition sequences. We sought to determine the utility of 3D ultrasound for epiaortic imaging in several patients undergoing elective cardiac surgery.

Received August 24, 2004; accepted August 25, 2004.

Address correspondence and reprint requests to: Daniel T Bainbridge, Assistant Professor, Department of Anesthesia and Perioperative Medicine, London Health Science Center, London, Ontario, Canada N6A 5A5; 519-685-8500 ext 35451 (e-mail: bainbridged@hotmail.com).

CASE REPORT

Case 1

A 67-year-old man presented for aortic valve replacement following several years of progressive aortic insufficiency. Following induction of anesthesia, sternotomy, and pericardotomy, the ×4 3D probe was placed directly onto the aorta, and the entire ascending aorta was scanned using live 3D. An area of plaque was identified on the posteromedial aspect of the aorta. The back wall of the ascending aorta was seen with a large thin plaque visible in the middle of the image. The plaque was determined to reside at the site of planned aortic cross clamp and so, while the original location of aortic cannula placement was retained, the cross clamp site was relocated more proximally. The patient did well with no clinically apparent neurological impairment postoperatively.

Case 2

This case involved an 82-year-old woman scheduled to undergo single-vessel coronary artery bypass and the repair of an 8-cm ascending aortic aneurysm. She was brought to the operating room and had invasive monitoring (arterial line and pulmonary artery catheter) placed in the usual fashion. Anesthesia was induced and surgery commenced. Following sternotomy and incision of the pericardium the ×4 3D probe was placed on the ascending aorta. An image was obtained that showed the aortic valve with the ascending aorta and aortic aneurysm. A calcified lesion was seen on the lateral wall of the aorta within the aneurismal dilation. Following initiation of bypass and application of the aortic cross clamp (distal ascending aorta before the innominate takeoff), the aorta was incised and exposed (Figure 1), revealing numerous small calcific plaques located throughout the ascending aorta. These plaques were easily palpated on the interior of the aorta. The ascending aneurysm was plicated and a left internal mammary artery–to–left anterior descending artery graft placed. The patient's postoperative course was unremarkable.

Case 3

This 78-year-old woman was scheduled to undergo elective 3-vessel coronary artery bypass surgery. The ×4 3D probe was initially placed on the closed pericardium; however, imaging was poor so the pericardium was opened and a sterile glove filled with saline was used for a standoff. Examination of the aorta revealed numerous calcified punctate

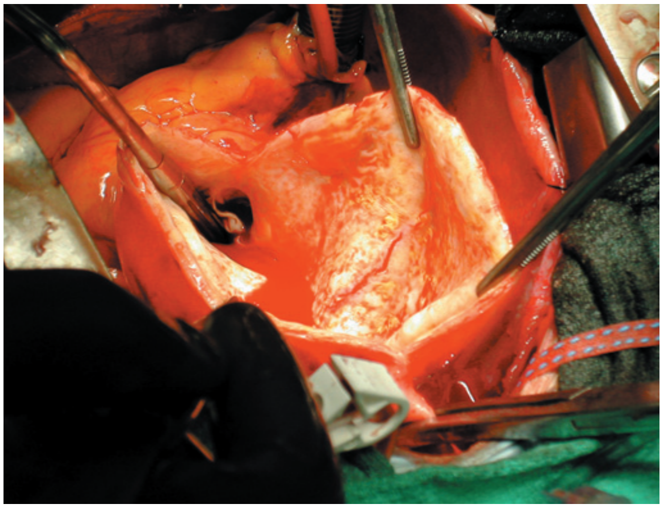

Figure 1. A picture of the aneurysm following initial incision.

plaques in the ascending arch. Uncertainty arose as to the significance of this finding, and we elected to rescan the aorta using the 2D probe. This scan again revealed calcification <2 mm in height (Figure 2). However, based on the 3D scan, we placed an aortic cross clamp high on the ascending aorta, and the operation occurred under a single clamp. Surgery continued uneventfully. Following removal of the cross clamp, the site was rescanned and the results showed no change. The patient did well following surgery and suffered no adverse neurological events.

Case 4

This 63-year-old woman was scheduled to undergo elective aortic valve replacement for aortic stenosis. 3D scanning revealed diffuse plaque throughout the aorta. The aorta was incised, confirming the diffuse disease evident on 3D scanning. The aorta was rescanned following removal of the aortic cannula. This scan revealed a new, mobile lesion on the anterior wall at the cannulation site. The patient had no clinically apparent neurologic changes postoperatively.

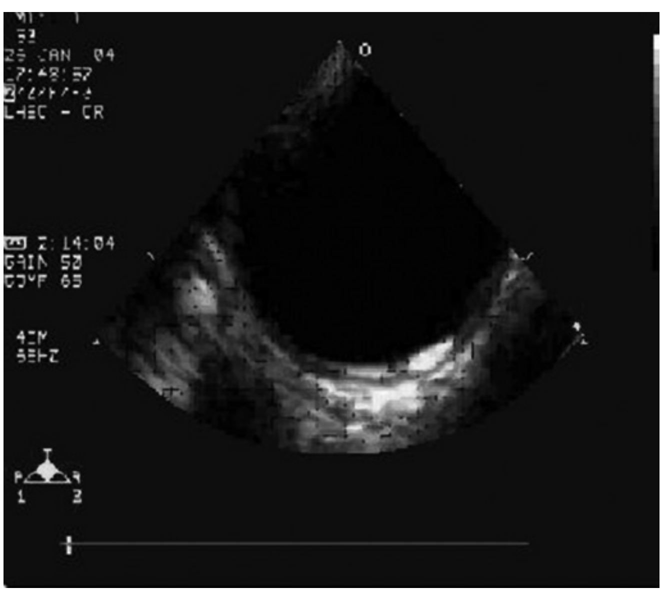

Figure 2. Two-dimensional image of the aorta showing calcification along the back wall.

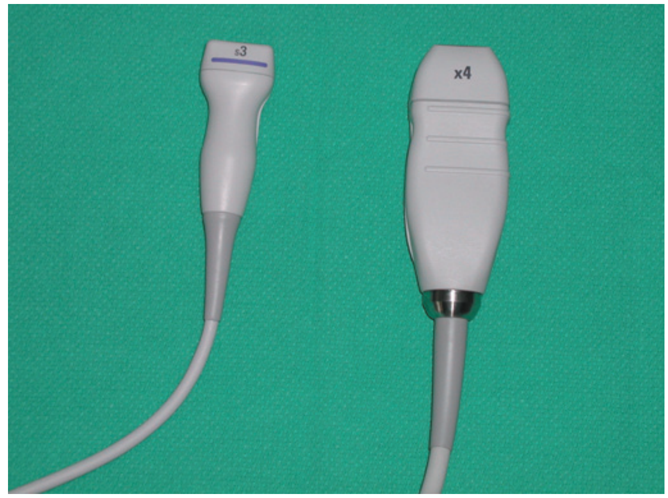

Figure 3. Comparison of the s3 2-dimensional probe (left) with the matrix ×4 probe (right).

DISCUSSION

Benefits of Epiaortic Scanning

Evaluation of the aorta is primarily focused on detecting and quantifying atherosclerosis within the aorta. Numerous studies using 2D epiaortic ultrasound have proven the utility of this approach in quantifying the degree of plaque formation within the ascending aorta [Ribakove 1992]. Importantly, the grade of atherosclerosis has been shown to predict the incidence of postoperative renal dysfunction, long-term neurologic outcome, and mortality [Davila-Roman 1999a, 1999b, Royse 2000]. In addition, several studies have demonstrated the utility of ultrasound in reducing stroke and neurocognitive dysfunction by directing aortic manipulation (cross clamp and cannulation) to sites free of plaque [Trehan 1997]. Finally, Ura et al have demonstrated that in patients with atheroma >4-mm epiaortic scanning following aortic decannulation revealed new lesions in more than 30% of the cases [Ura 2000].

The live 3D imaging system by Philips Medical allows 2 basic imaging modes, a live 3D mode and a full volume mode. The full volume mode acquires a larger image by gating the ultrasound acquisition to the heartbeat, using 8 cardiac cycles; the probe itself must remain motionless during the acquisition phase. During live 3D mode the images are displayed live, allowing the probe to be manipulated, but limiting the size of the interrogated area. With either technique, once the image is obtained it can be rotated or cropped in any plane. 3D color Doppler imaging is also available.

Live 3D was most useful in identifying and localizing the position of plaque within the aorta and correlating this data with the proposed sites of cross clamp and cannulation. Fol-

Figure 4. Demonstration of the saline-filled pocket at the end of the probe secured by a sterile elastic band used for scanning.

lowing this procedure, full volume mode was used to evaluate the proposed sites completely and ensure no plaque was missed during the live scanning process. In addition, full volume mode was useful to obtain images of the aortic root (sinotubular junction and aortic valve), providing discernable landmarks for reference.

2D versus 3D Imaging.

There appeared to be little difference in the sensitivity of 2D and 3D imaging to detect plaque within the aorta. In all cases in which both 2D and 3D imaging were employed, plaque identification was consistent between modalities; however, it was clearly more clinically apparent with the 3D imaging, which demonstrated the full extent the plaque. The primary advantage of 3D imaging was that it demonstrated the relative distribution of plaque within the aorta. 3D imaging was better able to display diffusely dispersed plaque. Additionally, the inclusion of discernable landmarks within the aorta (sinotubular junction, aortic valve) made the relative position of the plaques more easily comprehensible.

Limitations of 3D Imaging

Although the benefits of scanning the aorta with the 3D probe were clear, there were several notable limitations. The probe itself is larger and therefore more difficult to maneuver when trying to obtain images (Figure 3). This limitation is at least partially offset by the greater imaging volume of the 3D probe.

As can be seen from some of the provided 3D images, the anterior 25% of the aorta was difficult to visualize in the early studies. Initially, the probe was placed directly on the aorta with only a thin, sterile, plastic sheath surrounding it. Following difficulties with visualization a variety of standoffs were used. A sterile glove filled with saline was tried first; however, this method caused difficulties in direct visualization of the aorta and made directing the probe to the aorta problematic. A closed pericardium, saline bath, and standoff were variably explored with some improvement in the area of visualization; however, in case 3 the images were poor with the pericardium closed and improved significantly when the pericardium was subsequently opened. A reliable technique employing saline (approximately 30 mL) placed within the sterile sheath and then secured in place with a sterile elastic band (creating a saline filled pocket) provided the best standoff, allowing accurate imaging of the anterior wall (Figure 4).

Future Direction

Whether benefit will be appreciable from the implementation of 3D scanning of the aorta remains to be determined. Reliable improvement of visualization of the entire aortic wall is needed to allow a comprehensive aortic assessment. In addition, studies looking at 3D scanning are needed to see if there is any difference in the rate of detection of plaques using this method compared to the current practice of 2D imaging. Perhaps the biggest advantage realized to date has been to provide images of the aorta that could be easily understood from an anatomic perspective. Most apparently, surgical management based on location and extent of plaque will also need to be better defined.

REFERENCES

Cheitlin MD, Armstrong WF, Aurigemma GP, et al. 2003. ACC/AHA/ASE 2003 guideline update for the clinical application of echocardiography: summary article: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (ACC/AHA/ASE Committee to Update the 1997 guidelines for the Clinical Application of Echocardiography). Circulation 108(9):1146-62.

Davila-Roman VG, Kouchoukos NT, Schechtman KB, et al. 1999. Atherosclerosis of the ascending aorta is a predictor of renal dysfunction after cardiac operations. J Thorac Cardiovasc Surg 117(1):111-6.

Davila-Roman VG, Murphy SF, Nickerson NJ, et al. 1999. Atherosclerosis of the ascending aorta is an independent predictor of long-term neurologic events and mortality. J Am Coll Cardiol 33(5):1308-16.

Konstadt SN, Reich DL, Kahn R, et al. 1995. Transesophageal echocardiography can be used to screen for ascending aortic atherosclerosis. Anesth Analg 81(2):225-8.

Ribakove GH, Katz ES, Galloway AC, et al. 1992. Surgical implications of transesophageal echocardiography to grade the atheromatous aortic arch. Ann Thorac Surg 53(5):758-61, discussion 762-3.

Royse AG, Royse CF, Ajani AE, et al. 2000. Reduced neuropsychological dysfunction using epiaortic echocardiography and the exclusive Y graft. Ann Thorac Surg 69(5):1431-8.

Royse C, Royse A, Blake D, et al. 1998. Screening the thoracic aorta for atheroma: a comparison of manual palpation, transesophageal and epiaortic ultrasonography. Ann Thorac Cardiovasc Surg 4(6):347-50.

Trehan N, Mishra M, Dhole S, et al. 1997. Significantly reduced incidence of stroke during coronary artery bypass grafting using transesophageal echocardiography. Eur J Cardiothorac Surg 11(2):234-42.

Ura M, Sakata R, Nakayama Y, et al. 2000. Ultrasonographic demonstration of manipulation-related aortic injuries after cardiac surgery. J Am Coll Cardiol 35(5):1303-10.

Wilson MJ, Boyd SY, Lisagor PG, et al. 2000. Ascending aortic atheroma assessed intraoperatively by epiaortic and transesophageal echocardiography. Ann Thorac Surg 70(1):25-30.