Review Article

Transesophageal Echocardiography Evaluation of the Aortic Arch Branches

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Abstract

Visualization of aortic arch branches by transesophageal echocardiography has been technically challenging. Visualizing these vessels helps in identifying the extent of dissection of the aorta, assessing the severity of carotid artery stenosis, presence of atheromatous plaques, patency of the left internal mammary artery graft, confirmation of subclavian artery cannulation, confirming holodiastolic flow reversal in the left subclavian artery by spectral Doppler imaging in case of severe aortic regurgitation, and confirming the optimal position of the intraaortic balloon perioperatively. The information obtained is helpful for diagnosis, monitoring, and decision-making during aortic surgery.

Keywords: *Aortic arch, brachiocephalic artery, carotid artery, innominate artery, subclavian artery, transesophageal echocardiography*

Introduction

Visualization of aortic arch (AA) and its branches by transesophageal echocardiography (TEE) has been technically challenging. Visualizing these vessels help in identifying the extent of dissection of the aorta, assessing the severity of carotid artery stenosis, patency of the left internal mammary artery (LIMA) graft, confirmation of subclavian artery cannulation, confirming holodiastolic flow reversal in the left subclavian artery by spectral Doppler imaging in case of severe aortic regurgitation, and confirming the optimal position of the intraaortic balloon perioperatively. The information obtained is helpful for diagnosis, monitoring, and decision-making during aortic surgery.[1]

Anatomy of the Aortic Arch

The AA lies between the ascending and descending thoracic aorta, in the superior mediastinum. The AA begins at the origin of brachiocephalic artery. The distal AA becomes the descending thoracic aorta at the aortic isthmus. The AA gives off brachiocephalic (innominate), left carotid, and left subclavian arteries in that order [Figure 1].[2-4]

There are various anatomic variations of AA and its branches. Right-sided AA is prevalent in 0.1% of the population [Figure 2a and b]. An isolated left vertebral artery is seen in about 4% of population.[5]

Transesophageal Echocardiography Evaluation of Aortic Arch and Their Branches

The AA gives rise to three branches from its superior aspect.

- Innominate (brachiocephalic) artery
- Left common carotid artery
- Left subclavian artery.

Technique of Visualization

In the upper esophageal (UE) AA short-axis (SAX) view with the pulmonary artery being seen on the left side of the sector, the branch from the AA is commonly the left common carotid artery arising usually at 3 o'clock position [Figure 3a]. To visualize the origin of the left subclavian artery, the TEE probe is rotated counterclockwise, with the left subclavian artery being visualized at 1 o'clock position [Figure 3b]. Rotating the probe in a clockwise direction from the UE AA SAX view reveals an oblong-shaped aorta giving rise to the innominate or the brachiocephalic artery [Figure 3c].

Left Subclavian Artery

Visualization of the left subclavian artery is achieved by counterclockwise rotation of the TEE probe from the UE AA SAX

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view. To visualize the branches of the left subclavian artery, one needs to optimize the depth, use color Doppler flow mapping from the beginning, optimize the gain to eliminate the artifacts, reduce the velocity scale to suit the low velocity flows and center the image by probe manipulation. Once the above-mentioned system settings are achieved, start withdrawing the probe keeping the image in the center of the screen. The left subclavian artery takes a course parallel to the direction of the ultrasound beam giving rise to the LIMA inferiorly and the left vertebral artery superiorly [Figure 4a]. The sector angle may need adjustment between 60° and 90° to visualize the vertebral artery and the LIMA. Both the vertebral artery and LIMA may not be visualized in the same view. The branches can be identified by their characteristic flow patterns.[6] Normally, there are two types of vessels, high resistance and low resistance vessels. The spectral Doppler flow pattern in the high resistance vessels exhibits only a prominent systolic flow due to high vascular resistance of the downstream normal muscular vascular bed at rest, while the low resistance vessels exhibit a prominent systolic and a low-grade diastolic flow pattern due to low vascular resistance of the downstream normal cerebral vascular bed. Left subclavian artery being high resistance vessel exhibits a triphasic flow pattern [Figure 4b]. The three phases are steep systolic increase, followed by early diastolic flow reversal and late diastolic short forward flow. On the contrary, left vertebral artery demonstrates a prominent systolic and a low-grade diastolic flow pattern as it supplies the low-resistance cerebral vascular bed [Figure 4c]. The LIMA has a high-resistance flow pattern [Figure 4b]. The native flow in the LIMA exhibits predominant systolic flow pattern by the pulse wave Doppler. Following anastomosis of the LIMA to the left anterior descending artery, the pulse wave Doppler depicts a biphasic flow pattern, a systolic and a dominant diastolic flow pattern [Figure 4d].

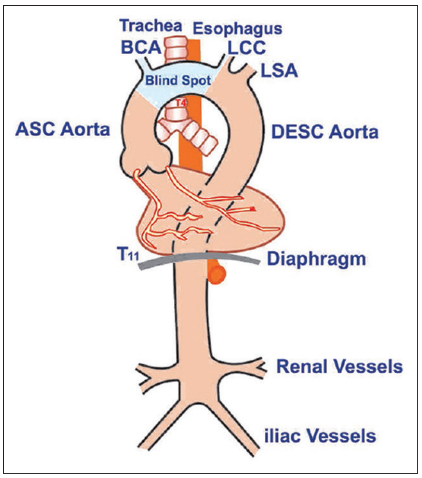

Figure 1: Illustrated anatomy of aortic arch and its branches. ASC aorta: Ascending aorta, BCA: Brachiocephalic artery, LCC: Left common carotid artery, LSA: Left subclavian artery, DESC aorta: Descending aorta, T11: 11th thoracic vertebra

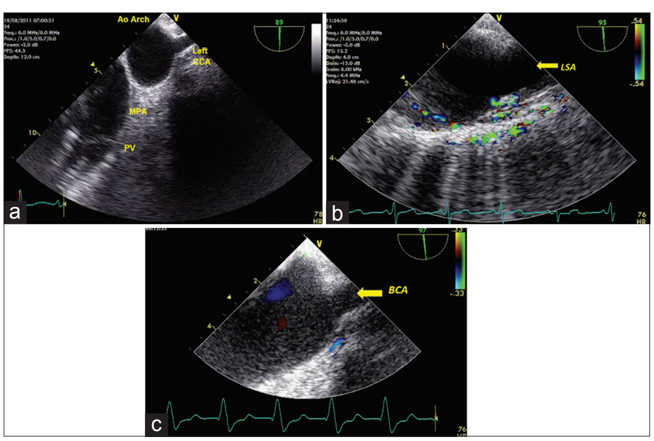

Figure 3: (a) Upper esophageal AA SAX view showing origin of the left common carotid artery with the pulmonary artery to the left. (b) Aortic arch giving rise to the LSA at 1 o'clock position. (c) Oblong-shaped aorta giving rise to the innominate artery. Ao arch: Aortic arch, Left CCA: Left common carotid artery, MPA: Main pulmonary artery, PV: Pulmonary valve, BCA: Brachiocephalic artery, LSA: Left subclavian artery, SAX: Short axis, AA: Aortic arch

Left Common Carotid Artery

Left common carotid artery is visualized by obtaining the UE AA SAX view. After optimizing the image for depth and color flow velocity scale, the TEE probe is withdrawn for

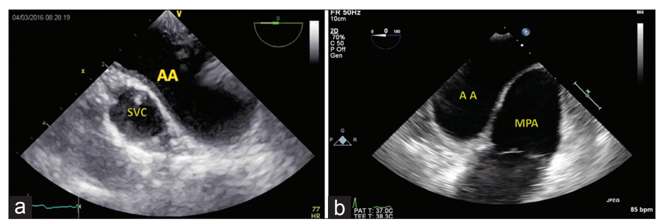

Figure 2: (a) Upper esophageal AA LAX view showing right-sided AA. (b) Upper esophageal AA LAX view showing left-sided AA. AA: Aortic arch, MPA: Main pulmonary artery, SVC: Superior vena cava

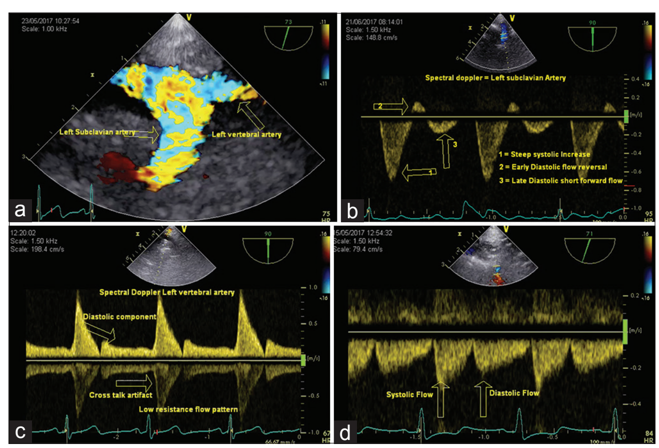

Figure 4: (a) Color flow Doppler showing the left subclavian and left vertebral arteries. (b) Spectral Doppler of left subclavian artery showing high resistance triphasic flow. (c) Spectral Doppler of left vertebral artery showing low resistance flow with diastolic component. (d) Spectral Doppler of left internal mammary artery following anastomosis to left anterior descending artery showing a biphasic flow pattern, a systolic and a dominant diastolic flow patter

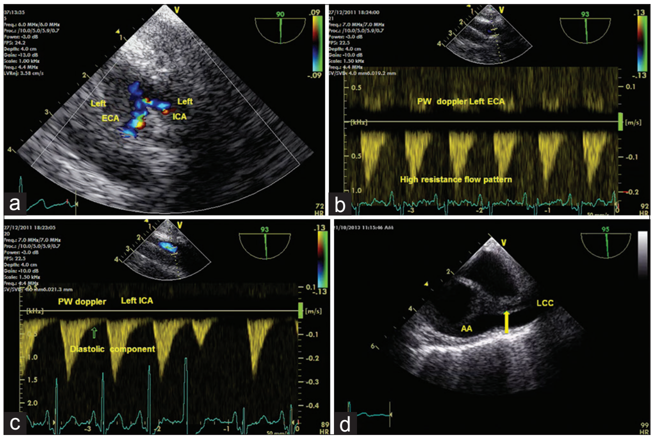

Figure 5: (a) Color flow Doppler of the left common carotid artery showing bifurcation into left ECA and ICAs. (b) Spectral Doppler of left ECA showing high resistance flow pattern. (c) Spectral Doppler of left ICA showing the low resistance flow pattern. (d) Dissected intimal flap extending into the origin of left common carotid artery. ECA: External carotid artery, PW: Pulse wave, ICA: Internal carotid artery

3–4 cm until the left common carotid artery bifurcates into left external and internal carotid arteries [Figure 5a]. The left external and left internal carotid arteries are recognized by their high resistance and low resistance flow patterns respectively by pulse wave Doppler imaging [Figure 5b-d].

Brachiocephalic Artery

Rotating the probe in a clockwise direction from the UE AA SAX view reveals an oblong-shaped aorta giving rise to the innominate or the brachiocephalic artery. The major limitation in visualizing this vessel is the presence of the underlying trachea and/or right bronchus. With TEE, the brachiocephalic artery is not visualized in 2/3rd of the patients. This can be overcome using the A-view catheter [Figure 6a].[7] On withdrawing the probe further, it bifurcates into the right subclavian and right common carotid arteries inferiorly parallel to the ultrasound beam [Figure 6b] which can be differentiated by their pulse wave Doppler flow patterns [Figure 6c and d].[8] The right subclavian artery Doppler is of high-resistance pattern and right common carotid artery flow is of a low-resistance pattern. This view is often referred to as the transpharyngeal view. Only a cranial part of this vessel is visualized in this view. One of the disadvantages of this view is that the probe may be pulled out of the esophagus and may be difficult to reinsert during the surgical procedure. Visualizing these vessels helps in identifying the extent of dissection of the aorta and presence of atheromatous plaques [Figure 6e and f].

Conclusion

TEE evaluation of AA branches provides useful information to diagnose pathological conditions including extension of aortic dissections. TEE examination can be completed within a very short time and can even be superior to CT scan in unstable critically ill patients. The

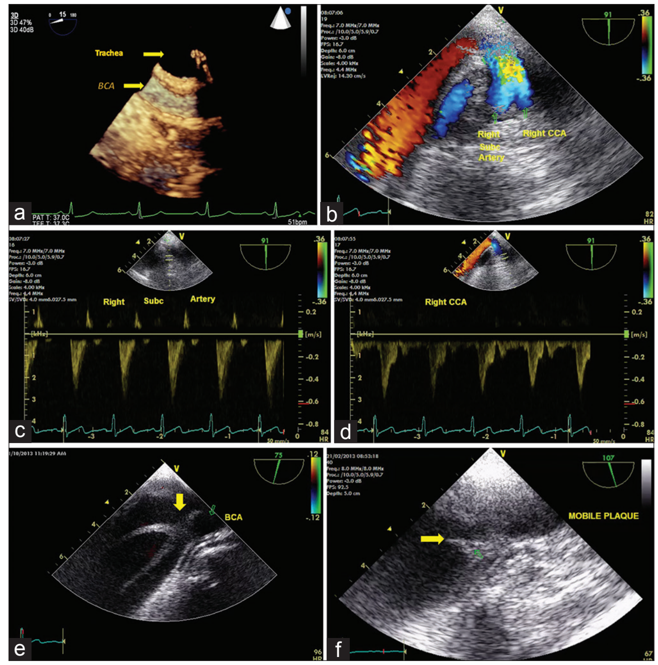

Figure 6: (a) Three-dimensional view showing BCA in long axis and trachea with the A-View catheter *in situ*. (b) Color flow Doppler of the BCA bifurcating into right subclavian and right common carotid arteries. (c) Spectral Doppler of the right subclavian artery showing high resistance flow. (d) Spectral Doppler of the right CCA showing low resistance flow. (e) Dissected intimal flap extending into the origin of the BCA. (f) Mobile plaque visualized at the origin of the BCA. BCA: Brachiocephalic artery, CCA: Common carotid artery

information obtained is helpful for diagnosis, monitoring, and decision-making during AA surgeries.

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Conflicts of interest

There are no conflicts of interest.

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