Positioning an Intraaortic Balloon Pump Using Intraoperative Transesophageal Echocardiogram Guidance

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A 72-year-old man with an ejection fraction of 25% is scheduled to undergo elective coronary artery bypass graft using cardiopulmonary bypass. Because of the high-risk nature of the operation, the surgeon wants to insert an intraaortic balloon pump (IABP) before initiating cardiopulmonary bypass. An intraoperative transesophageal echocardiogram (TEE) is requested to ensure correct placement. (Anesth Analg 2011;113:40–3)

The intraaortic balloon pump (IABP) has been in clinical use for >40 years and is the most commonly used mechanical assist device for patients with low cardiac output after cardiac surgery.[1,2] It has also been suggested that high-risk patients undergoing coronary artery bypass graft may benefit from its placement before beginning the surgical procedure.[3] The IABP consists of a flexible catheter with an inflatable balloon at the end and is typically inserted percutaneously via the femoral artery into the descending thoracic aorta (Fig. 1). Its function is to improve myocardial oxygen delivery while simultaneously reducing myocardial oxygen consumption. As diastole begins with closure of the aortic valve, the balloon rapidly inflates and displaces blood into the aortic arch and ascending aorta. This increase in blood volume results in an increased diastolic pressure in the ascending aorta, and thus an increase in coronary perfusion pressure and myocardial oxygen delivery. Immediately before systole and opening of the aortic valve, the balloon deflates, pulling blood away from the heart, which decreases end-diastolic aortic pressure and left ventricular afterload. The tip of the balloon catheter should be 1 to 2 cm distal to the left subclavian artery (LSCA) to appreciate maximal hemodynamic benefit.[4] This position ensures that blood flow to the brain and upper extremities will not be compromised, will maximize IABP augmentation, and will reduce the incidence of occluding abdominal visceral arteries by the distal part of the balloon.

Although TEE is often used for positioning an IABP in the operative setting, it is not required and, in fact, its use is not discussed in current American Society of Anesthesiologists/Society of Cardiovascular Anesthesiologists guidelines.[5] In the cardiac catheterization suite, fluoroscopy tends to be the standard imaging modality because it is readily available. In some patients, fluoroscopy may even be preferred because it can be used to help direct the guidewire through tortuous femoral vessels that TEE cannot image. In the intensive care unit, chest radiographs are the standard way to confirm IABP placement. The IABP tip just distal to the aortic knob is often used as the radiographic landmark, although data suggest that 2 cm above the carina may be a more reliable guide.[6] When no imaging modalities are available, the correct insertion depth can be estimated by measuring the groin-to-manubrium distance.

PREPLACEMENT EXAMINATION

One of the advantages of intraoperative TEE is that contraindications for using an IABP can be excluded. Aortic regurgitation should be evaluated using color-flow Doppler in the midesophageal aortic valve long-axis view. Any aortic regurgitation more than mild in severity should be considered an absolute contraindication because diastolic inflation of the balloon will increase the regurgitant volume, potentially distending the left ventricle. Pathology of the descending aorta and aortic arch, such as aneurysms and dissections, also typically preclude IABP placement. If absolutely necessary, however, IABPs have been successfully used in the setting of dissections when TEE is used to ensure placement in the true lumen.[7] Significant atherosclerosis of the descending aorta or aortic arch should be considered a relative contraindication, because plaques can be dislodged, causing a distal embolus. In the setting of cardiac failure, however, clinical judgment should be used as to whether these risks outweigh the benefits that an IABP can provide.

PLACEMENT OF IABP

Percutaneous placement of the IABP is done most frequently via the Seldinger technique using the femoral arteries. Open arteriotomies can also be performed for access and, rarely, when femoral obstruction is present, insertion via the subclavian artery or direct insertion into the ascending aorta has been reported.[8,9] Regardless of entry site, it is important that the balloon portion lies between the LSCA and any visceral arteries to avoid obstruction of the arch vessels or important abdominal branches (see below). Once arterial access is obtained and, in most models, an introducer sheath placed, a guidewire is positioned into the femoral artery and advanced into the descending thoracic aorta. It is critically important to verify

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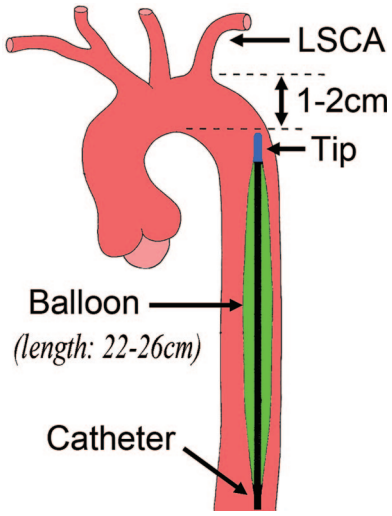

Figure 1. Diagram showing correct placement of an intraaortic balloon pump. Note that the tip is 1 to 2 cm from the left subclavian artery (LSCA) take-off. Dotted lines indicate the LSCA take-off (top) and the level of the inferior border of the transverse arch (bottom). Typical balloon lengths are 22 to 26 cm, according to manufacturers' data. Adapted from (11) with permission.

the presence of this wire in the aorta before advancing the IABP catheter over it. A descending aortic short- or long-axis view can be obtained and should demonstrate the echo-dense wire within the aortic lumen (Fig. 2A). The IABP is then advanced over the guidewire (Fig. 2B) (see Supplemental Digital Content 1, Video 1, http://links.lww.com/AA/A250; see Appendix for video legend).

IABPs are sized according to the volume of helium gas used to inflate the balloon, with 40 cc being the adult size most commonly inserted in the United States. Because larger volumes require a longer balloon, selection is based upon patient height to avoid occlusion of the renal arteries. Those patients at the extremes of height, usually considered >6′ (183 cm) or <5′4′′ (162 cm), typically receive 50-cc and 30-cc balloons, respectively. Inexperienced echocardiographers will occasionally report that a patient's descending aorta diameter is not big enough for larger-volume balloons. Although it is true that total occlusion of the descending aorta is not desirable (maximum benefit is received when 80%–90% of the lumen is occluded during diastole), the largest inflated balloon diameters range only from 14 to 16 mm and rarely pose a problem with respect to width.[10]

Once the IABP has been successfully placed into the thoracic aorta, the guidewire is removed to prevent the IABP tip from being confused with the wire. The IABP tip should be guided to a position 1 to 2 cm distal to the LSCA. This can be done using the descending aortic long-axis view to identify the tip of the IABP and withdrawing the probe until the view transitions to the upper-esophageal aortic arch short-axis view with the LSCA take-off visualized (see Supplemental Digital Content 2, Video 2, http://links.lww.com/AA/A251; see

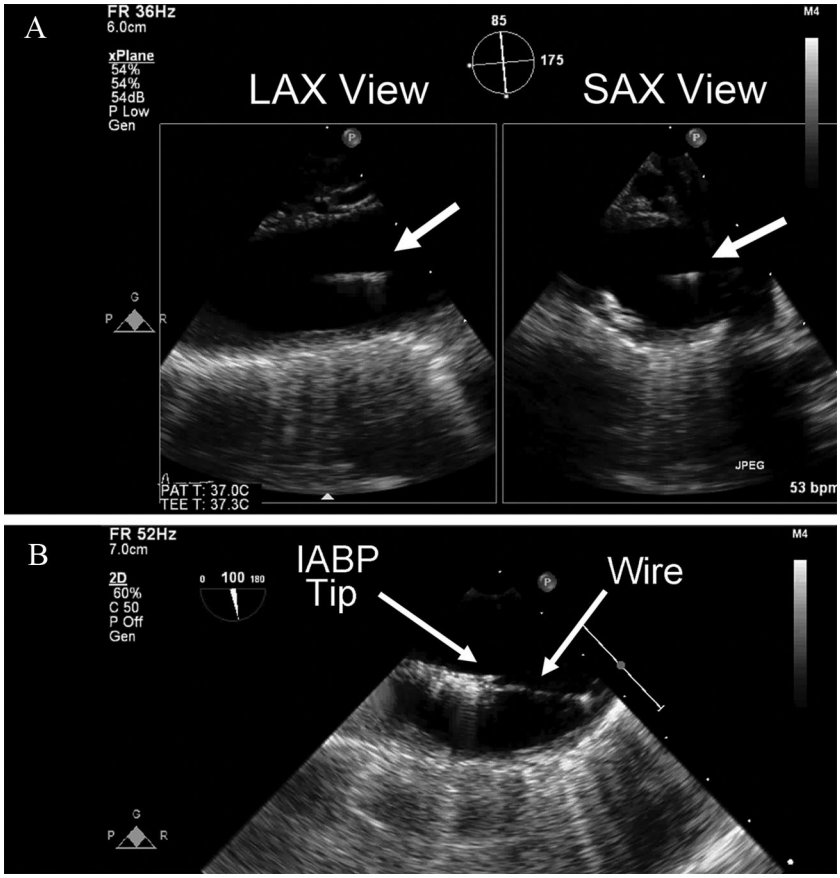

Figure 2. A, View of the descending aorta in both long (LAX) and short (SAX) axes. The arrows point to the guidewire. B, LAX view of the descending aorta showing a deflated balloon being advanced over the previously placed guidewire. IABP = intraaortic balloon pump.

Appendix for video legend details). Distance of the tip from the LSCA can be judged by first marking the probe depth at the mouth and noting how many finger breadths the probe is withdrawn until the LSCA take-off is seen (see Supplemental Digital Content 3, Video 3, http://links.lww.com/AA/A252; see Appendix for video legend details). Another previously described method also uses the descending aortic long-axis view to identify the IABP tip in relation to the transverse portion of the aortic arch.[11] The probe is then turned to the patient's right to view the transverse aortic arch, and the tip should be even with the inferior border (Fig. 1).

POSTPLACEMENT EXAMINATION

Because of the large acoustic impedance mismatch between blood and the gas-filled balloon and the strong specular reflections caused by the catheter, an inflated balloon creates multiple shadowing and reverberation artifacts. Direct imaging of the device is nearly impossible with an inflated balloon, and the catheter will be visible only during systole, when the balloon is deflated. However, the rapid cycle of inflation and deflation creates a typical pattern that can be used to verify that the IABP is functioning properly (see Supplemental Digital Content 4, Video 4, http://links.lww.com/AA/A253; see Appendix for video legend details). If this pattern is not seen and a large volume of bubbles is present within the aorta, balloon rupture should be suspected and the IABP immediately removed. Injury to the aorta, such as dissection or perforation, is rare after initial placement, with an incidence of about 0.5%.[12] Nevertheless, the aortic arch and descending aorta should be thoroughly visualized for changes from the preplacement examination. If significant atheromatous disease was previously noted, this area should be inspected to determine whether the atheroma was disturbed or dislodged. Unfortunately, most vascular complications—including femoral artery injury, femoral pseudoaneurym, and limb ischemia—cannot be diagnosed using TEE.

SUMMARY

A systematic TEE examination performed before, during, and after placement of an IABP facilitates prompt recognition of contraindications, guides correct placement, and permits periodic assessment of function. The Teaching Points table provides a summary of the authors' approach to the various stages of IABP placement.

APPENDIX: VIDEO CAPTIONS

Video 1. Descending aortic long-axis (LAX) view showing the echo-dense guidewire within the lumen of the descending thoracic aorta. The intraaortic balloon pump (IABP) catheter can be seen advancing over the guidewire using the Seldinger technique.

Video 2. Descending aortic long-axis (LAX) view showing the tip of the balloon catheter within the proximal descending thoracic aorta. The tip is centered in the imaging sector. The probe is then withdrawn and turned slightly clockwise until the upper-esophageal aortic arch short-axis (SAX) view is developed. SCA = subclavian artery.

Video 3. Technique to measure the distance from the left subclavian artery to balloon catheter tip. Once the catheter tip is visualized in descending aortic long-axis view, probe position at the patient's mouth is marked with the thumb and index finger. The probe is then withdrawn, as in Video 2, until the left subclavian artery (LSCA) is visualized. The distance from the patient's mouth to thumb/index finger represents the distance from the left subclavian artery to tip of balloon catheter.

Video 4. Descending aortic short-axis (SAX) and long-axis (LAX) views demonstrating a functional intraaortic balloon pump. Acoustical shadowing and multiple reverberation artifacts occur during diastole when the balloon is inflated. The catheter and far-field structures are visible only during systole when the balloon is deflated.

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REFERENCES

1. Baskett RJF, Ghali WA, Maitland A, Hirsh GM. The intraaortic balloon pump in cardiac surgery. Ann Thorac Surg 2002; 74:1276–87
2. Hernandez AF, Li S, Dokholyan RS, O'Brien SM, Furguson TB, Peterson ED. Variation in perioperative vasoactive therapy in cardiovascular surgical care: Data from the Society of Thoracic Surgeons. Am Heart J 2009;158:47–52
3. Dyub AM, Whitlock RP, Abouzahr LL, Cina CS. Preoperative intra-aortic balloon pump in patients undergoing coronary bypass surgery: A systematic review and meta-analysis. J Card Surg 2008;23:79–86
4. Papaioannou TG, Stefanadis C. Basic principles of the intraaortic balloon pump and mechanisms affecting its performance. ASAIO J 2005;51:296–300
5. Thys DM, Abel MD, Brooker RF, Cahalan MK, Connis RT, Duke PG, Nickinovich DG, Reeves ST, Rozner MA, Russell IA, Streckenbach SC, Sears-Rogan P, Stewart WJ. Practice guidelines for perioperative transesophageal echocardiography: an updated report by the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists task force on transesophageal echocardiography. Anesthesiology 2010;112:1–13

Teaching Points: TEE During Phases of IABP Placement

Preplacement	Placement	Postplacement
Assess aorta for contraindications:	Confirm:	Evaluate:
Absolute	Guidewire in descending aorta	Typical inflation artifacts during diastole
> Mild aortic regurgitation	Guidewire in true lumen if aortic dissection present	Aorta for signs of injury
Relative	IABP tip 1–2 cm distal to left subclavian artery	Changes in previously noted atherosclerotic plaques
Aneurysms		Increase in aortic regurgitation
Dissection flaps		
Significant atherosclerosis		

6. Kim JT, Lee JR, Kim JK, Yoon SZ, Jeon Y, Bahk JH, Kim KB, Kim CS, Lim YJ, Kim HS, Kim SD. The carina as a useful radiographic landmark for positioning the intraaortic balloon pump. Anesth Analg 2007;105:735–8
7. Nakatani S, Beppu S, Tanaka N, Andoh M, Miyatake K, Nimura Y. Application of abdominal and transesophageal echocardiography as a guide for insertion of intraaortic balloon pump in aortic dissection. Am J Cardiol 1989;64:1882–3
8. Raman J, Loor G, London M, Jolly N. Subclavian artery access for ambulatory balloon pump insertion. Ann Thorac Surg 2010;90:1032–4
9. Rehfeldt KH, Click RL. Intraoperative transesophageal imaging of an intra-aortic balloon pump placed via the ascending aorta. J Cardiothorac Vasc Anes 2003;17:736–9
10. Rastan AJ, Tillmann E, Subramanian S, Lehmkuhl L, Funkat AK, Leontyev S, Doenst T, Walther T, Gutberlet M, Mohr FW. Visceral arterial compromise during intra-aortic balloon counterpulsation therapy. Circulation 2010;122:s92–9
11. Shanewise JS, Sadel SM. Intraoperative transesophageal echocardiography to assist the insertion and positioning of the intraaortic balloon pump. Anesth Analg 1994;79:577–80
12. Arafa OE, Pederson TH, Svennevig JL, Fosse E, Geiran OR. Vascular complications of the intraaortic balloon pump in patients undergoing open heart operations: 15 year experience. Ann Thorac Surg 1999;67:645–51