Positional Obstruction of the Superior Mesenteric Artery by an Intra-aortic Balloon Pump Placed Through Subclavian Artery Approach

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Patients awaiting orthotopic heart transplant (OHT) often require temporary mechanical circulatory support. Although the intra-aortic balloon pump (IABP) placed through percutaneous femoral arteriotomy is the most commonly used form of mechanical circulatory support in the United States, this approach requires the patient to remain immobile, making it suboptimal for extended use. Our center recently developed a novel technique to insert an IABP through the subclavian artery (SCA), allowing the patient to ambulate. Briefly, a polytetrafluoroethylene graft is anastomosed in an end-to-side fashion to the right or left SCA. A valve is secured within the other end of the graft, and the IABP is advanced through the graft into the descending aorta. The proximal radio-opaque IABP marker is positioned 2 cm superior to the carina with the distal marker near the L2 vertebra. Although several groups have reported various techniques for SCA IABP insertion, no consensus exists regarding the optimal position of the distal tip in stable position in the aorta, 3 cm inferior to the origin of the SMA (Figure 1A; Movie I in the Data Supplement). Vascular ultrasound showed the distal IABP tip from anteroposterior x-ray showed the proximal IABP marker in proper position 2 cm superior to the carina (Figure 1A) and the distal tip in stable position from prior (Figure 1B). Vascular ultrasound showed the distal IABP tip in stable position in the aorta, 3 cm inferior to the origin of the SMA (Figure 2A; Movie I in the Data Supplement) and nonobstructive waveforms (with counterpulsation) in all abdominal vessels (Figure 2B and 2C).

The following day, the patient observed that the pain was inconsistently associated with eating and was occasionally associated with simply sitting upright for more than several minutes. Interestingly, the pain did not occur every time he ate or sat up but was invariably relieved when he would lie supine. Repeat vascular ultrasound with the patient sitting upright showed the distal IABP tip entering and obstructing the SMA (Figure 3A; Movie II in the Data Supplement). Extension of the torso while lying supine caused the SMA to pull out of the SMA (Figure 3B; Movie III in the Data Supplement). Repeating these provocative maneuvers revealed that the IABP tip would either advance down the descending aorta or move into the SMA when the patient sat upright. When the IABP did enter the SMA, the hemodynamic obstruction was significant (Figure 3C). The patient returned to the operating room, and the IABP was repositioned under fluoroscopy farther down the abdominal aorta. The patient’s symptoms resolved and he was bridged successfully to OHT after 13 days of support.

Case 1

A 60-year-old, 180 cm tall man with a Maquet 8F 50cc right SCA IABP complained of nonbloody diarrhea and severe abdominal pain radiating to the back 6 days after implant. He denied urinary symptoms and had no history of pancreatic, hepatic, or ulcerative disease. On physical examination, there was diffuse abdominal tenderness without peritoneal signs or distention. Bowel sounds were intact. Laboratories and ultrasonography of the liver, pancreas, and biliary system were unremarkable. Anteroposterior chest x-ray showed the proximal IABP marker in proper position 2 cm superior to the carina (Figure 4A) and the distal marker in stable position from prior (Figure 4B). Vascular ultrasound showed the distal IABP tip in stable position in the aorta, 3 cm inferior to the origin of the SMA (Figure 5A; Movie I in the Data Supplement) and nonobstructive waveforms (with counterpulsation) in all abdominal vessels (Figure 5B and 5C). Repeat vascular ultrasound with the patient sitting upright showed the distal IABP tip entering and obstructing the SMA (Figure 6A; Movie II in the Data Supplement). Extension of the torso while lying supine caused the SMA to pull out of the SMA (Figure 6B). The patient was scheduled to have the IABP repositioned, but a donor heart became available that night and the patient proceeded with OHT after 15 days of support.

Case 2

A 53-year-old, 175 cm tall man with a Maquet 8F 50cc right SCA IABP developed maroon stools and abdominal pain 7 days after implant. The positional nature of the pain was similar to Case 1. Because of the melena, the patient underwent an esophagogastroduodenoscopy, and when this failed to reveal a source of bleeding, a colonoscopy. This showed ischemic colitis at the cecum with adherent clot (Figure 4) that had not been present 3 weeks earlier. Computed tomography performed to evaluate for transmural colitis clearly showed the IABP tip in the SMA (Figure 5A and 5B), although vascular ultrasound later showed the tip in the aorta. Later that night, the patient’s pain recurred, and the distal tip of the IABP could not be seen on anteroposterior x-ray (Figure 6A). Lateral x-ray showed the distal tip in the abdomen at a sharp angle consistent with the origin of the SMA (Figure 6B). The patient was scheduled to have the IABP repositioned, but a donor heart became available that night and the patient proceeded with OHT after 13 days of support.

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Discussion
We report for the first time 2 cases of transient IABP migration into the SMA. Abdominal pain in a heart failure patient awaiting OHT has a differential that includes hepatic congestion and diffuse ischemia because of globally decreased perfusion or embolic phenomena but also includes mechanical complications of the IABP. The distal end of the IABP is sharply pointed with a low profile that allows for percutaneous femoral insertion. However, when inserted through the SCA, this point can slip into a visceral vessel with patient flexion/extension. With the increasing commonality of extended mechanical circulatory support reliance with active ambulatory rehabilitation while awaiting OHT, it is important that the cardiovascular specialist recognize SCA IABP–related vascular obstruction promptly because the IABP can be easily repositioned to avoid bowel ischemia or SMA dissection. Although we have had success using ultrasonography with provocative maneuvers to demonstrate IABP migration, other forms of abdominal imaging such as x-ray and computed tomography can be helpful as well. The preferred imaging modality should be chosen by the clinician on a patient-specific basis.

The proximal marker of the SCA IABP must be placed inferior to the origin of the left SCA to avoid damage to the arch vessels. However, the optimal placement for the distal tip of the SCA IABP is not known. Advancing the IABP downward may compromise other abdominal vessels, whereas withdrawing the IABP upward may compromise the celiac axis (from the tip) or the arch vessels (proximally). Therefore, we recommend patient-specific selection of an appropriate IABP size with provocative maneuvers in the operating room under fluoroscopy and ultrasonography to evaluate the movement of the distal tip in response to patient position.

Disclosures
None.

References

Key Words: intra-aortic balloon pumping • mesenteric arteries • subclavian artery

Figure 1. A, Anteroposterior chest x-ray showing the proximal intra-aortic balloon pump (IABP) marker (white arrow) in proper position 2 cm above the carina. B, Anteroposterior abdominal x-ray showing the distal IABP marker (black arrow) in stable position in the upper abdomen.
Figure 2. A, Two-dimensional ultrasound showing the distal tip of the intra-aortic balloon pump (IABP) in the abdominal aorta 3 cm inferior to the origin of the superior mesenteric artery (solid arrow, IABP tip; bracket, aorta; open arrow, superior mesenteric artery origin). Spectral Doppler showing nonobstructive waveforms (with counterpulsation) in (B) the celiac axis and (C) the superior mesenteric artery (SMA). MID indicates middle; and PRX, proximal.

Figure 3. Two-dimensional ultrasound of the superior mesenteric artery (SMA) and aorta. A, With the patient sitting upright, the intra-aortic balloon pump (IABP) enters and obstructs the SMA (solid arrow, IABP tip; open arrow, celiac axis; bracket, SMA; star, aorta). B, When the torso is extended, the IABP pulls out of the SMA (solid arrow, IABP tip; open arrow, SMA; star, aorta). C, Spectral Doppler showing hemodynamically significant obstruction of the SMA by the IABP. Obstruction was variable based on patient position, and accurate Doppler measurements were technically challenging to obtain. Peak systolic velocity was ≥281 cm/s although depending on patient position could be significantly higher. Counterpulsation and diastolic flow were lost. MID indicates middle.
Figure 4. Colonoscopic view of the cecum showing ischemic colitis; this section of colon was normal 3 weeks earlier.

Figure 5. A, Computed tomographic axial view and (B) sagittal view showing the distal intra-aortic balloon pump tip (arrows) in the superior mesenteric artery.

Figure 6. A, Anterioposterior abdominal x-ray with inability to visualize the distal intra-aortic balloon pump tip. B, Lateral x-ray showed the tip (arrow) at a sharp angle consistent with entry into the superior mesenteric artery.
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