Use of contrast-enhanced echocardiography to confirm endo-aortic balloon placement in robotic mitral valve surgery

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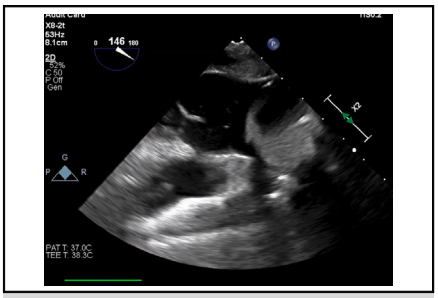


Intraoperative TEE of a 61-year-old woman with a contrast-enhanced endo-aortic balloon.

CENTRAL MESSAGE

We describe our safe, reproducible technique of an echocardiography contrast impregnation to help guide the placement of an endo-aortic balloon in robotic mitral valve surgery.

Video clip is available online.

Interest in robotic cardiac surgery continues to increase in an effort to meet the patient demand for effective, minimally invasive techniques. For robotic cardiac surgery to be performed as safely and effectively as the gold standard midline sternotomy, a series of innovative techniques and tools are required to allow standard principles of cardiac surgery to translate to robotic techniques.[1] One challenge is effective occlusion of the ascending aorta to allow for cardioplegia delivery and venting. There are 2 primary options for aortic occlusion: crossclamping the aorta in the operative field and the use of an endo-aortic balloon inserted via the femoral artery either through a side-port on the arterial cannula or a separate arterial puncture site. One particular challenge is accurate positioning of the endo-aortic balloon, ensuring a safe distance from the aortic valve and innominate artery. We describe our technique of an echocardiography contrast impregnation to help guide placement of endo-aortic balloon in robotic mitral valve surgery.

Patient selection is key to a successful robotic mitral valve operation because many complications are associated with patient-specific factors.[1] The endo-aortic balloon used in our practice is the "IntraClude" intra-aortic occlusion device (Edwards Lifesciences). The "IntraClude" intra-aortic occlusion device is designed to be used with 21F and 23F Edwards EndoReturn arterial cannulas, as well as 19F Edwards introducer sheaths. To ensure complete occlusion of the aorta, ascending aortic diameter should not exceed 40 mm.

Bilateral radial artery catheters are used for invasive monitoring. This allows for timely intervention should the endo-aortic balloon migrate and occlude the brachiocephalic or left subclavian arteries. Although this is a rare occurrence, this affords an extra level of security. The endo-aortic balloon is prepared on the back table while the patient is being prepped. Our choice of contrast is Lumason (Bracco Diagnostics Inc). The Lumason comes as a powder that is reconstituted and mixed in 25 mL of heparinized saline totaling 30 mL used to inflate the balloon.

Our preference for cardiopulmonary bypass access is percutaneous cannulation. Alternatively, direct cannulation can be performed using a limited incision made in the right groin to expose the femoral vessels. The robot is docked in the usual fashion. Heparin is administered after wire access is obtained in the femoral artery and vein, and placement has been confirmed to be in the descending thoracic aorta and right atrium. The femoral arterial cannula, femoral venous cannula, superior vena cava cannula, and

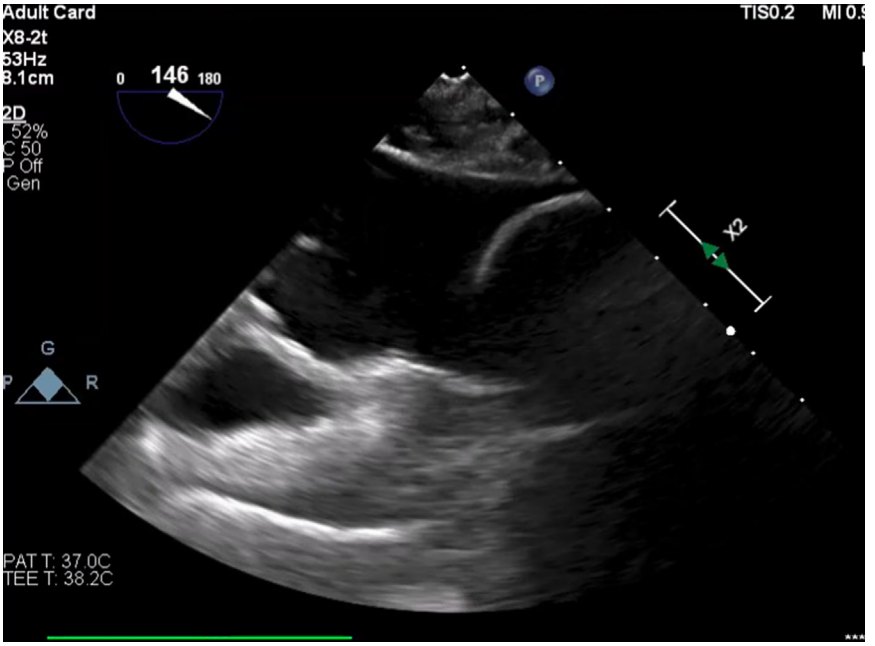


FIGURE 1. Intraoperative TEE of a 61-year-old woman without contrast in the endo-aortic balloon.

endo-aortic balloon are passed under continuous transesophageal echocardiography (TEE) guidance.

Once the pericardium is open, the team is ready for aortic occlusion. The endo-balloon is inflated using Lumason echocardiography contrast, and slack is removed from the catheter to facilitate ideal placement 2.5 cm from the aortic valve. After approximately 75% of the balloon is inflated, adenosine is administered followed rapidly by completion of balloon occlusion of the aorta and infusion of cardioplegia. Adenosine administration is not required but is standard in our practice. The position of the endo-balloon is continuously monitored by TEE and hemodynamic changes in the right radial artery. At this point, the left atrium is opened and mitral repair is performed in the usual fashion. After

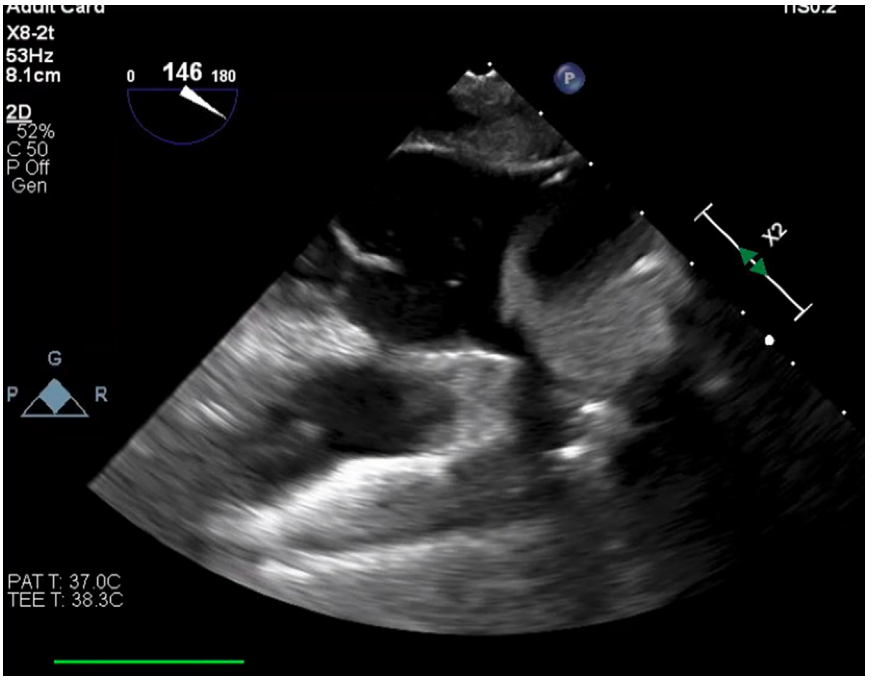
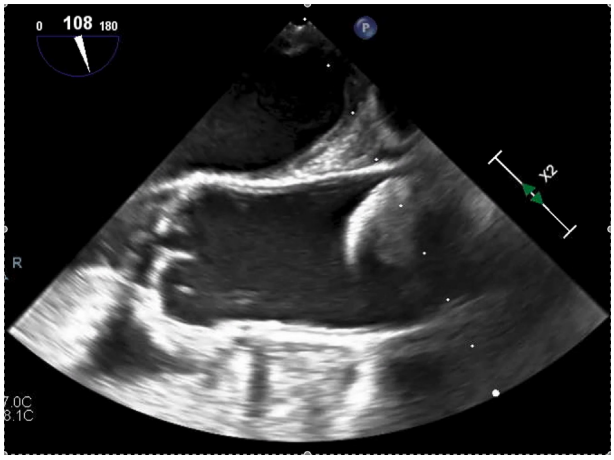


FIGURE 2. Intraoperative TEE of the same 61-year-old woman from Figure 1 now with a contrast-enhanced endo-aortic balloon.



VIDEO 1. TEE images of cardioplegia being delivered into the aortic root of an aorta that is occluded using an endo-aortic balloon. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00509-1/fulltext.

the left atrium is closed, the endo-aortic balloon is deflated and the patient is weaned from cardiopulmonary bypass.

Effective clamping of the aorta is essential to permit a successful robotic mitral valve surgery. There are currently 2 strategies for effective aortic clamping: intrathoracic clamping of the aorta and endo-aortic balloon occlusion of the aorta. Both approaches to aortic clamping have a role in robotic surgery. Intrathoracic aortic clamping reduces operative time, cost, and procedural complexity.[2] However, placement of an intrathoracic clamp occupies valuable space in a confined operative field and has been associated with injury to the pulmonary artery, left atrial appendage, and left main coronary artery. It is also crucial to position the clamp posteriorly enough such that the left robotic working arm does not inadvertently interact with the clamp and cause undo torque on the aorta.

The endo-aortic balloon mitigates the aforementioned risk associated with intrathoracic clamping, but it is not entirely risk free. The use of the endo-aortic balloon is a less stable platform and may migrate during the operation.[1] We have found that adding a contrast agent to the endo-aortic balloon enhances visualization of the balloon, which helps with initial placement and allows for easy monitoring of placement during the case. Figure 1 shows a 61-year-old woman without a contrast-enhanced endo-aortic balloon. Figure 2 shows the same 61-year-old woman now with a contrast-enhanced endo-aortic balloon. The Video 1 demonstrates TEE images of cardioplegia being delivered into the aortic root of an aorta that is occluded using an endo-aortic balloon. Endo-aortic balloon occlusion is associated with increased aortic dissection and conversion to sternotomy.[3] Our institutional use has also experienced injury to the aortic valve due to improper placement of the balloon before routine use of the contrast-enhanced endo-aortic balloon resulting in unplanned sternotomy and aortic valve repair. Our program has now used contrast-enhanced endo-aortic balloon placement in approximately 80 consecutive robotic mitral valve surgeries. Since the institution of contrast-enhanced endo-aortic balloon placement, there have been no complications related to balloon positioning or migrations. Lumeson is a common medication used for contrast-enhanced echocardiography. Side effects of Lumeson include dizziness, difficulty breathing or swallowing, and cough. The dose of Lumeson given using our technique is diluted to approximately 10% of which is used for standard contrast-enhanced echocardiography.

Another strategy used in many robotic surgical programs is the use of indocyanine green (ICG) with the Firefly feature on the da Vinci Xi robotic surgical platform (Intuitive Surgical Inc). With this method, the endo-aortic balloon is filled with an ICG solution. When the balloon is inflated in the ascending aorta, Firefly mode is activated and the location of the balloon shows up as a green band within the aorta. This method lacks the ability to precisely locate the balloon with respect to critical structures within the aortic root and sinotubular junction. A potential application is using both methods by inflating the balloon with both contrast and ICG; however, an ideal ratio of contrast to ICG has yet to be described.

Careful operative planning is the key to a successful robotic mitral valve surgery. Comprehensive robotic mitral valve programs should be facile with both intrathoracic and endo-aortic occlusion strategies. The strategy for aortic occlusion should be thoughtful and based on patient-specific factors that would suggest effective aortic occlusion with the lowest risk of associated morbidity. Our use of contrast-enhanced endo-aortic balloon occlusion helps guide safe endo-aortic balloon placement and mitigate the risk of balloon migration.

Conflict of Interest Statement

W.Y.S.: investigator, speaker, and advisory board for Abbott, Artivion, Edwards Lifesciences, Medtronic, Terumo, and Aortic. All other authors reported no conflicts of interest.

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