How I do it: minimally invasive Cox-Maze IV procedure

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Submitted Nov 01, 2013. Accepted for publication Dec 21, 2013.
doi: 10.3978/j.issn.2225-319X.2013.12.01
Scan to your mobile device or view this article at: http://www.annalscts.com/article/view/3247/4122

Clinical vignette

Our patient is a 66-year-old female with a 2-year history of atrial fibrillation (AF) and mitral valve prolapse who presented with dyspnea on exertion. She was found to be in AF upon her admission electrocardiogram. A transthoracic echocardiogram was performed demonstrating moderate-to-severe mitral regurgitation (MR) with a left atrial (LA) diameter of 5.1 cm and normal left ventricular (LV) function. After completion of her workup, it was decided that the patient would best be treated by a minimally invasive Cox-Maze IV (CMIV) and concomitant mitral valve procedure given her significant MR and symptoms. This article and accompanying video will discuss how the minimally invasive CMIV procedure is performed.

Surgical techniques

Preparation

In order to perform a mini-thoracotomy mitral valve maze procedure, the patient is positioned with the right chest elevated 45° and the hips flat. Transesophageal echocardiography (TEE) is performed to assess the MR, and examine for a patent foramen ovale or clot in the LA appendage. The aortic valve is also evaluated since significant aortic insufficiency is a contraindication to this approach. The patient is prepped and draped in the usual fashion.

Exposition

A bronchial blocker is used to allow for deflation of the right lung. A right subinguinal incision is made and the femoral artery and vein are exposed, and subsequently the patient is fully heparinized. Proximal and distal control is obtained and the vessels are cannulated for cardiopulmonary bypass (CPB). Cannula position is documented with TEE, followed by a 5-6 cm right mini-thoracotomy incision made in the submammary crease and tunneled up to the 4th intercostal space in women, or over the 4th intercostal space in men. The chest is then entered through the 4th intercostal space and the right lung is deflated. A small segment of posterior 5th rib is removed and a soft tissue retractor is placed. Care is taken not to do any rib spreading in order to minimize postoperative pain. CPB is initiated at normothermia. Carbon dioxide is infused into the chest throughout the case to prevent air embolism. Pericardial stay sutures are placed in the pericardium and brought out through the lateral chest wall in order to expose the right atrium and interatrial septum. Dissection of the pericardium is performed up to the mid-ascending aorta and then down to the diaphragm. A port is placed in the 6th intercostal space in the posterior axillary line and a 5 mm 30° high definition endoscope is used to provide visualization.

Operation

The minimally invasive CMIV procedure can be broken down into three components: (I) right pulmonary vein (PV) isolation; (II) the right atrial lesion set; (III) the LA lesion set and oversewing of the LA appendage. We refer to the video and the article included in this special issue by Robertson *et al.* which describes the detailed steps to this operation. Key steps for each of these components are listed below. It should be noted that each bipolar radiofrequency (RF) lesion is created by 2-3 ablations with the clamp to

ensure lesion transmurality.

Pulmonary vein isolation

It is important to first dissect the intra-atrial septum as completely as possible to remove the fat and to allow for clamping of a generous cuff of LA tissue. After blunt dissection of the right PVs, an umbilical tape should be passed around them to aid in safe passage of the bipolar RF clamp around the veins. If in AF, the patient is cardioverted to sinus rhythm at this point. Typically, three ablations are performed to isolate as large an atrial cuff around the PVs as possible. Exit block is confirmed by attempting to pace from both the superior and inferior right PV.

Right atrial lesion set

The right atrial lesion set is performed through three separate purse strings during CPB on the beating heart. The first purse string is placed just above the intra-atrial septum between the inferior vena cava (IVC) and superior vena cava (SVC). An ablation line is created from the SVC to the IVC by placing one jaw of the clamp through this purse string. Another line of ablation is created through this purse string across the right atrial free wall towards the atrioventricular (AV) groove near the acute margin of the RV. Care is taken not to ablate over the AV fat pad in order to protect the right coronary artery. Methylene blue is used to mark the end of this ablation line. A second purse string is placed at this mark to allow for the insertion of a 3 cm linear cryoprobe. This is used to create an endocardial cryoablation down toward the tricuspid valve annulus. All cryoablations are performed using nitrous oxide at –60 ℃ for three minutes. A third purse string is placed at the base of the right atrial appendage. A bipolar RF ablation is created along the right atrial free wall down toward the SVC with care taken to leave at least 2 cm between this ablation line and the ablation line extending from the SVC/IVC. This line is also created along the aortic side of the appendage to avoid injury to the sinoatrial node. The linear cryoprobe is placed through this 3rd purse string and an endocardial cryoablation is performed down to the tricuspid annulus at the 10 o'clock position.

LA lesion set

This lesion set is made after aortic cross clamping and administration of cold blood cardioplegia into the aortic root. An atriotomy is performed and the LA lift system is positioned to provide exposure of the mitral valve and PVs. As a first step, the LA appendage is oversewn in two layers using a running 4-0 Prolene suture. The bipolar RF clamp is used to create an ablation line from the inferior aspect of this incision down toward the left inferior PV. The distal aspect of this ablation line is marked with methylene blue. A second ablation line is then created from the superior aspect of this incision over the LA roof toward the mouth of left superior PV. A final RF ablation is created from the inferior aspect of the left atriotomy down toward the mitral valve annulus and again marked with methylene blue. This ablation is connected to the mitral valve annulus by performing an endocardial cryoablation with a t-shaped cryoprobe while simultaneously performing an epicardial cryoablation over the coronary sinus with a linear cryoprobe. In order to complete the isolation of the posterior left atrium, the two ablation lines to the left inferior and superior PVs are connected behind the PVs and along the lateral ridge by performing endocardial cryoablations with the t-shaped cryoprobe. If there is any question, we perform an epicardial cryoablation with the linear cryoprobe in order to ensure that the bipolar RF ablation lines are connected. A standard mitral valve repair and annuloplasty follows.

Comments

The development of the CMIV procedure has simplified the surgical management of AF. Compared to the "cut-and-sew" Cox-Maze III operation, the CMIV procedure is both technically easier and faster to perform, due to the use of ablation technology to replace the surgical incisions. In our experience, CMIV performed through sternotomy shortened mean cross-clamp time for a lone Cox-Maze from 93±34 to 41±13 minutes (P<0.01), and from 122±37 to 92±37 minutes (P<0.01) in those undergoing concomitant cardiac surgery (1,2). Results for the CMIV have been excellent and are comparable to those seen with the Cox-Maze III procedure (3). This simplified procedure has allowed for a broader application of this operation in patients in whom AF intervention is indicated.

Advances in thoracoscopic technology and the development of minimally invasive surgical instruments allow this procedure to be performed via a minimally invasive approach. Unpublished data from our institution has shown this approach decreased intensive care unit (ICU) stay by one day and hospitalization by two days when compared to patients receiving a CMIV ± mitral operation through a sternotomy approach (P<0.001). The minimally invasive approach also reduces the number

of major complications by 50%, allowing for a better utilization of hospital resources. This was achieved with only a marginal increase in aortic cross clamp time (82±33 *vs*. 69±33 minutes, P<0.001) and a trend towards decreased perioperative mortality. Thus, performing the CMIV procedure via a minimally invasive right thoracometry approach is an attractive option for the surgical treatment of AF.

Acknowledgements

We would like to acknowledge Peggy Frisella, RN for her help with video editing. Support in part by National Institutes of Health grants R01 HL032257 and F32 HL082129. RJD receives research grants and educational funding from AtriCure, Estech, and Edwards.
Disclosure: RJD also receives consultant fees from AtriCure and Medtronic. Other co-authors declare no conflict of interest.

Cite this article as: Saint LL, Lawrance CP, Leidenfrost JE, Robertson JO, Damiano RJ Jr. How I do it: minimally invasive Cox-Maze IV procedure. Ann Cardiothorac Surg 2014;3(1):117-119. doi: 10.3978/j.issn.2225-319X.2013.12.01

References

1. Weimar T, Bailey MS, Watanabe Y, et al. The Cox-maze IV procedure for lone atrial fibrillation: a single center experience in 100 consecutive patients. J Interv Card Electrophysiol 2011;31:47-54.
2. Gaynor SL, Diodato MD, Prasad SM, et al. A prospective, single-center clinical trial of a modified Cox maze procedure with bipolar radiofrequency ablation. J Thorac Cardiovasc Surg 2004;128:535-42.
3. Damiano RJ Jr, Schwartz FH, Bailey MS, et al. The Cox maze IV procedure: predictors of late recurrence. J Thorac Cardiovasc Surg 2011;141:113-21.

