

Transapical off-pump mitral valve repair with Neochord Implantation (TOP-MINI): step-by-step guide

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Introduction

A wide variety of surgical approaches for mitral valve repair (MVR) are available. Recent studies have demonstrated that the techniques which “respect rather than resect” the diseased portion of the mitral valve (MV) have comparable clinical outcomes and potentially superior results in terms of physiology (1). Artificial chordal implantation has received increased attention as an MVR strategy during the last few decades, especially when performed through a minimally invasive approach.

The Transapical Off-Pump Mitral Valve Repair with Neochord Implantation (TOP-MINI) is a new MVR option that has been approved for patients presenting with severe mitral regurgitation (MR) due to leaflet(s) prolapse or flail (2-4). The procedure is performed using the NeoChord DS1000 system (NeoChord, Inc., Eden Prairie, MN) under guidance of direct 2D and 3D transesophageal echocardiography (TEE) (5,6) for both implantation and tension adjustment of the neochordae.

The aim of this article is to describe the TOP-MINI procedure in a step-by-step fashion.

NeoChord delivery system

The NeoChord DS1000 consists of:

- (I) a single-use, hand-held instrument designed to load and deploy commercially available ePTFE sutures (CV-4) through exchangeable cartridges;
- (II) a tethered Leaflet Verification Display that enables confirmation of leaflet capture in the distal clamp

of the device through four fibre optic lights. These lights reflect the tissue in between the device jaws (blood = red, leaflet = white).

Preparation

The TOP-MINI can be performed in an ordinary cardiac surgery operating theatre. Optimal TEE imaging systems are mandatory because the procedure relies on imaging quality. Stand-by cardiopulmonary bypass should be ensured.

The patient is under general anesthesia and mechanically ventilated through a double-lumen endotracheal tube, fully monitored and supine. The patient is then rolled onto the right side (approx. 30) to better expose the left side of the chest. A safety-net preparation of the femoral vessels is used as described for transapical TAVI.

The surgical technique

Step 1

A standard left lateral mini-thoracotomy is performed in the fifth intercostal space to access the left ventricular (LV) apex after selective left lung exclusion. The LV access site is laterally identified by gently pushing 2-3 cm away from the true apex, under 2D-TEE monitoring. Simultaneous multi-plane or ‘X-plane’ imaging was obtained from the mid-esophageal long-axis (ME LAX) and mitral commissure (MC) views. The correct localization of the entry site allows the surgeon to face the MV directly with the delivery

system, to navigate across the subvalvular apparatus safely and to give a more natural orientation to the neochordae inside the LV.

A plastic pocket is attached under the site of the skin incision to collect blood loss during the transapical manoeuvres.

Two concentric purse-string sutures are placed in a crown-like manner with 4–5 large custom-made Teflon pledgets.

Heparin is given at a dose of 100 U/kg to reach an activated clotting time >300 seconds. In the meantime, the delivery system is loaded with one ePTFE suture and its specific needle. The suture is held on its distal end by a mosquito, which has to be marked with a different colour for each neochorda in order to recognize the precise position and function of each suture.

Step 2

A transapical ventriculotomy is performed with an 11 scalpel blade and slightly dilated with a long straight clamp. Once the device enters the LV, the apical purse-strings are gently tightened to minimize blood leakage and allow the device to slide. Blood loss is gathered by a cell-saver system.

Step 3

The NeoChord DS1000 is directed towards the left atrium on 2D-TEE guidance (X-plane ME LAX + MC views) avoiding native subvalvular apparatus coupling. The key point is to keep the device under the A2-P2 segments to stay clear from the native chordae during systole and cross the valve as the diastolic opening occurs.

Step 4

Once the MV is overcome, echocardiographic imaging switches to full online 3D (surgical view) and the device is shifted towards the prolapsing segment. Anomalous movements of the leaflets on the screen or any feeling of advancing resistance with the instrument suggest an unsuccessful valve crossing and the manoeuvre must be repeated.

Step 5

When an appropriate position has been achieved, the jaws of the device are opened and the leaflet is grasped. The leaflet is correctly captured when all four fibre optic monitor lights turn from red to white. At this time, the surgeon has

to keep a firm hold of the instrument and carefully push the needle forward to pierce the valve segment. Then, the needle is retracted in a smooth continuous motion until its distal tip and the GoreTex suture loop exit the instrument. When the GoreTex suture has been engaged and retraction of the needle starts, the mosquito must be released.

The device is finally pulled out from the ventricle with the jaws opened while the two ends of the suture are gripped manually. As the retrieval is complete, the apical purse-strings are temporarily tight.

Tension is applied to the neochorda and if it significantly reduces the MR, a girth hitch knot is secured to the leaflet, locking one head of the suture on the valve segment (while two ends remain outside the chest for final fixation on the apex).

Additional neochordae are implanted by repeating the procedure to achieve maximal competence of the valve. At least three sutures are needed to balance the tension per neochorda and avoid excessive mechanical stress with the risk of early suture dehiscence.

At the end of any Neochord Implantation, blood volume loss is checked and, if needed, it is processed and re-infused in order to maintain optimal hemodynamic stability.

Step 6

When a satisfactory number of chordae are deployed, the apical purse-strings are tied. An Eye needle is used to pass through a big round pledget through all the neochordae, which in turn is fixed with a 2-0 prolene suture over the ventriculotomy and tourniquets. Once the correct amount of stretch is established, Nissen forceps are placed below each tourniquet and the neochordae are tightened securely onto it. These manoeuvres improve hemostasis because the apical purse-strings are not stretched directly by the neochordae and avoid the possibility that small pledgets could be pulled inside the heart muscle with consequent elongation of the neochordae.

Step 7

Protamine sulfate is used to reverse the heparin, the pericardium is partially closed and the mini-thoracotomy is closed in layers. A Painbuster catheter (Painfusor, Plan 1 Health, Italy) is used for delivery of local anesthetic.

Postoperative management

The patient can be awakened and extubated in the

operating theatre. Transfer to the intensive care unit is recommended for at least a couple of hours after surgery for full monitoring of the patient's condition.

No specific postoperative antithrombotic therapy is required, unless otherwise indicated. Single antiplatelet therapy is a valuable therapeutic option.

Conclusions

The step-by-step standardization of TOP-MINI provides an effective tool among the available minimally invasive MVR techniques. This procedure is feasible and highly reproducible with significant clinical results. It does not require any structural change to the dynamics of the operating room or cardiac surgery team. The TOP-MINI procedure does indeed push the boundaries of minimally invasive MVR techniques to a new level.

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