Video-atlas on minimally invasive mitral valve surgery—the Mohr technique

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Minimally-invasive mitral valve surgery was introduced into the surgical routine by Alain Carpentier, one of the pioneers of mitral valve surgery, in 1996 (1). It was at this time that minimally-invasive access was also performed at the Leipzig Heart Center for the first time. Since then, this technique has become routine at our institution with an annual number of up to 400 cases (2). It has been shown to be a safe technique not only in patients with impaired left ventricular function (3) and in patients of advanced aged (4), but also in selected patients who have had a previous sternotomy (5). In the majority of cases, the mitral valve is operated under direct vision. However, some cases are performed using pure videoscopic vision, as it has been promoted by Hugo Vanerman and others (6).

The goal of minimally-invasive mitral valve surgery is to perform the operation with the same high repair rate compared to conventional mitral valve surgery through a median sternotomy and without putting the patient at a higher surgical risk. Avoiding sternotomy has major advantages for the patient, such as decreased surgical trauma and therefore improved recovery, less postoperative pain and improved cosmesis. These issues are of major importance for patients. There are, however, specific contraindications to this access, which have to be taken into account. In particular, a heavily calcified mitral valve annulus or severe annular abscess formation with the need to perform extensive annular reconstruction techniques should necessitate a conventional approach. Previous right chest surgery with severe adhesions of the right lung to the chest wall is an additional contraindication to minimally-invasive access. In addition, aortic valve regurgitation >I° is in our experience also a reason to perform a conventional sternotomy, in order to avoid insufficient administration of cardioplegia.

In all other cases, minimally-invasive access can be used to perform the surgery. An article featured in this issue, "Consensus statement on Minimally Invasive Mitral Valve Surgery", will address important issues when and when not to perform minimally-invasive access.

In 2000 Mohr and von Oppel (7) introduced the "Loop technique". This technique simplified even complex repairs of mitral disease using initially self-manufactured polytetrafluoroethylene neochordae (Gore-Tex loops), which became later available as premanufactured loops in different lengths. This technique has been shown to achieve excellent surgical results with a very high rate of mitral valve repair even in complex mitral valve pathologies (2). We were further able to demonstrate in a prospective randomized trial, that the "loop technique" had specific advantages compared to the leaflet resection technique in patients with mitral valve prolapse (8). Aside from significantly greater length of coaptation, patients undergoing the "loop technique" also received significantly larger annuloplasty rings in this study.

In summary, the "loop technique" simplifies mitral valve repair, especially through a minimally-invasive surgical approach.

Description of the surgical technique

The minimally-invasive approach needs to be standardized. There are, however, small variations in the individual operative set-up of different surgeons who perform this technique at our institution.

Cannulation of the groin vessels

Following an oblique incision of about 3 cm over the

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right groin, the femoral artery and vein are dissected only superficially. Purse string sutures are placed on both vessels and are cannulated using Seldinger's technique under ultrasound guidance. In all patients undergoing isolated mitral valve surgery over 75 kg in weight, an additional venous neck cannula is placed preoperatively into the superior vena cava by the anesthetist to improve venous drainage. In cases of poor venous drainage, an additional cannula can also be placed into the superior vena cava through minimally-invasive access. If the femoral artery is not suitable for cannulation due to severe calcifications, or in cases in which retrograde aortic perfusion is not recommended, cannulation of the axillary artery may be an option. The patient is put on-pump before the right chest is entered. This enables free access to the pericardium without the need to use a double lumen tube.

Lateral thoracotomy and additional incisions

After positioning the patient on their back, with the right side moderately lifted up using a folded towel under the patient's back and slightly outwards positioning of the right arm, the chest is entered in the 4th or 5th intercostal space. It is very helpful to mark the anticipated area of skin incision before the foil is applied, because, especially in women, the foil is used to push the breasts anteriorly and superiorly. It is also advisable to mark the midline of the sternum, in case urgent sternotomy is required. Conversion to full sternotomy must be available at all times!

In obese women with large breasts, it is very useful to enter the chest superior to the breast after the right breast has been pushed downwards.

The surgical incision into the thoracic cavity should obey the following principle: "Always higher than you think; in men, one intercostal space higher and in women, two intercostal spaces higher!" A soft tissue retractor is used to open the incision and an additional retractor is inserted to access the right chest. Retraction sutures can be placed on the diaphragm for better visualization of the pericardium or the diaphragm can be pushed away using a flexible blade, which is fixed in between the lower rip and the retractor.

The first additional incision should be positioned anteriorly in a safe distance to the right internal thoracic artery. This incision will be used for the holder of the left atrial retractor blade and may also be used for getting the cardioplegia line/root vent out. The incision for the cross-clamp should be directed towards the ascending aorta, without putting any force onto the aorta after the left atrium has been retracted. Care must be taken to avoid interference with the camera, which should be inserted anterior and superior to the cross-clamp, achieving a direct view of the mitral valve. One or two of these additional incisions can be used later for getting the chest drains out.

Visualization of the mitral valve

Following incision of the pericardium about 3 cm above the phrenic nerve, pericardial retraction sutures may be applied and brought out laterally. Using a purse string suture, a needle vent is brought into the aortic root for application of cardioplegia and later venting of the aortic root.

After aortic cross clamping, the left atrium is entered through the interatrial groove. It is advisable to apply the cross-clamp during a short duration of complete circulatory arrest to avoid the potential risk of aortic dissection. The left atrium is lifted up using a retractor blade, which is available in different sizes and lengths. In some cases, the blade used for pushing the diaphragm away can also be used to improve visualization of the mitral valve by pushing the inferior part of the left atrial incision downwards.

Mitral valve repair using the loop technique

After assessing mitral valve pathology, adequate lengths of premanufactured Gore Tex loops are placed onto the specific papillary muscle (PM). The lengths of the loops are calculated using a special measuring caliper. The measuring device is placed onto the tip of the relevant PM and at the free edge of the leaflet to measure the adequate length of the neo-chords. On average, the mean length for the posterior leaflet is between 12-14 mm and for the anterior leaflet between 22-24 mm. Each set of neo-chords is composed of four loops, which are anchored to the specific PM by getting two sutures through the muscle, which are then knotted over two teflon pledgets. The free edges of the loops are then positioned at the corresponding free edges of the leaflets using an additional 4-0 Gore suture for each loop. It is important to anchor the loops in the body of the PM to prevent tearing of the loops and to grasp enough leaflet tissue. If less than four neo-chords are necessary, two loops may be sutured to the leaflet at once. The maximum number of loops is therefore 16, with eight loops to each leaflet and eight loops coming from each PM. For a simple posterior leaflet prolapse P2, loops in the majority of

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cases coming from the postero-medial PM are enough to accomplish an adequate reconstructive result.

It is important not to cross the midline of the anterior and posterior mitral leaflet with the loops and therefore, loops from the antero-lateral papillary muscle should support the areas A1, P1 and A2 and P2 up to the midline and the loops from the postero-medial papillary muscle should support the leaflet areas P2/A2 from the midline and P3/A3. Each repair is secured and followed by stabilizing the annulus in a standard fashion.

The left atrium is closed in a standard fashion, using 3×0 monofilament sutures. Following left atrial and left ventricular de-airing maneuvers, the cross-clamp is released again during a short period of circulatory arrest and a pacing wire is attached to the right ventricle while the heart is still empty.

Finally, the patient is weaned from cardio-pulmonary bypass and the mitral valve repair is assessed by transesophageal echo. If the repair is adequate and adequate de-airing has been performed, cardiopulmonary bypass in reinstituted and the root vent is removed. The patient is then again weaned from bypass. Following decannulation and insertion of one or two chest tubes, the thorax is closed in a routine fashion.

In summary

Minimally-invasive mitral valve surgery can be used as a standard technique for mitral valve surgery, even in complex cases of mitral valve repair. The "Loop Technique" simplifies mitral valve repair through this access and accomplishes excellent surgical results. Minimally-invasive mitral valve surgery offers decreased surgical trauma, less pain, improved cosmesis and quicker recovery, which are the major advantages of this technique over conventional access through full sternotomy and of most importance for patients.

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