Mitral Valve Replacement With Homograft

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Replacement of the mitral valve with a mitral valve homograft is appealing because it involves natural tissues and a valve designed specifically to withstand the full contractile force of the ventricle while providing unobstructed flow from the atrium to the ventricle. Anticoagulant medications should not be needed, provided that atrial contraction is normal.

Transplantation of the natural human mitral valve to the mitral position has been tried both experimentally and clinically. Robiesek\(^1\) reviewed the early work on this procedure. Successful replacement of the mitral valve with a homograft requires achieving secure fixation of the papillary muscles of the graft to the papillary muscles of the recipient. Yankah and associates\(^2\) called attention to the "the locus minoris resistentiae," the papillary muscle union site. Different methods of achieving this have been tried. The most successful approach involves side-by-side suture of the donor muscle to the recipient muscle, as described by Acar and colleagues.\(^3\) This approach has proven more consistently successful than attaching the papillary muscles in end-to-end fashion supported by pledgets on the muscle or with sutures brought to the outside of the ventricle.

SURGICAL TECHNIQUE

The operation is performed via a median sternotomy. The Carpentier–DelaCroix retractor system is used to obtain maximum exposure. Cardiopulmonary bypass is established using two 24-French venous uptake cannulae, one passed through the right atrial wall into the superior vena cava and the other passed through the right atrial wall into the inferior vena cava. Vacuum-assisted venous drainage is used. Oxygenated blood is returned through a 24-French cannula in the ascending aorta. The aorta is occluded, and myocardial protection is provided during the period of ischemia by intermittent infusion of hypothermic cardioplegia solution retrograde through a cannula placed in the coronary sinus. A 10-French vent catheter is placed in the left atrium via the right superior pulmonary vein. The left atrium is opened on the right side through the interatrial groove. The self-retaining retractor blades are positioned for optimal exposure.
1 The mitral valve is removed by incising the valve circumferentially. The incision is placed near the fibrous annulus of the valve. Some of the anterior leaflet is retained, especially in the region near the aortic valve.

2 The chordae tendinae are removed from the tips of the papillary muscles. The papillary muscles are studied. Only Aear type I or II are able to adequately support a homograft valve, meaning that a single-or double-headed papillary muscle must be present. Retraction on the papillary muscles exposes the muscular trabeculations (bands) that attach the papillary muscles to the ventricular wall (see inset). These are divided to create space between the papillary muscles and the free wall of the left ventricle in which the graft papillary muscles may be imbedded.
The size of the homograft is determined. Originally, measurements taken from echocardiography were used to size the graft, with the most important dimension the height of the anterior leaflet measured during diastole in the patient. Today, the diameter of the annulus mitral valve is measured after the valve is excised, and a mitral homograft of similar diameter is chosen. This is based on data presented by Sakai and colleagues relating the length of mitral valve chordae tendinae to the diameter of the mitral valve. Using 2/0 braided polyester suture, horizontal mattress stitches for mitral valve annuloplasty are placed around the perimeter of the mitral annulus while the valve is thawing.

After the valve is thawed, it is trimmed. The myocardium of the atrium and the ventricle is cut away from the valve annulus, leaving just enough tissue to allow needle penetration without entering leaflet tissue. The papillary muscles are shortened, leaving 10 mm of muscle below the chordal attachments.

Implantation begins with fixation of the papillary muscles. Exposure is enhanced by placing a retractor blade through the mitral valve annulus into the left ventricle anteriorly. The posterior papillary muscle is implanted first. Two mattress stitches are placed at the base of the papillary muscle. The suture material is 5-0 Cardionyl (Péters, Bobigny, France), a monofilament suture chosen for its flexibility, knot security, and fine-needle compatibility.

The two mattress stitches are placed in the homograft’s papillary muscle and then passed through the recipient’s papillary muscle. The stitches are placed at the base of the papillary muscle so that the homograft’s papillary muscle will lie exactly side-by-side with the recipient’s papillary muscle and the tips of the muscles will be at the same level when the graft muscle is drawn into place between the recipient’s papillary muscle and the ventricular wall. Exposure is enhanced by placing a traction stitch through the papillary head that supports the commissure, which is invariably at the apex of the recipient’s papillary muscles. The stitches are tied so as to securely approximate the muscular tissues without weakening or cutting through the papillary muscles.
Two interrupted stitches are placed at the anterior margin of the papillary muscles to secure the side-by-side approximation of the muscles.

Two interrupted stitches are placed posteriorly to finish lining up the muscles. Multiple stitches are then placed to secure the tips of the papillary muscles, with care taken to not interfere with the chordae tendinae. Vertical mattress sutures may be required. The anterior papillary muscles are approximated in a similar fashion.

The homograft annulus is attached to the recipient’s mitral annulus using continuous stitches with 4/0 polypropylene suture. The homograft’s fibrous trigones of the graft are lined up with the recipient’s fibrous trigones. The homograft’s leaflet tissues are distributed uniformly around the annulus. The replaced valve is supported by remodeling annuloplasty using a Carpentier Physio (Edwards Lifesciences LLC, Irvine, CA) annuloplasty ring. The size of the device is chosen to match the size of the homograft’s anterior leaflet, as in standard mitral valve repair operations. The device is attached to the annulus by the previously placed sutures (see inset). Competence of the repair is tested by infusing saline solution under pressure into the left ventricle and by echocardiography after closing the atrium is closed and the heart resuscitated.
Comments

Operations to replace the mitral valve with a homograft have been limited by the ability to securely attach the papillary muscles. This procedure can be performed reproducibly now using techniques described by Acar and colleagues.3

Determining the size of the mitral valve homograft was based initially on the height of the anterior leaflet of the diseased mitral valve being excised, as recommended by Acar.3 This yielded an oversized valve for the orifice at the annulus in some cases. Sakai and colleagues1 measured the annulopapillary muscle distances in 57 normal human hearts and showed that this distance correlates with the mitral annular diameter. Thus, the most reliable means of choosing the properly sized mitral valve homograft is to simply measure the diameter of the recipient’s mitral valve annulus.

The crux of the operation is attaching the homograft's papillary muscles to the recipient's papillary muscles using a side-by-side technique. In the past, it was generally thought that heavy, strong suture material supported with a pledget would produce the best outcomes. Acar3 took a different approach and recommended multiple stitches of 5/0 monofilament suture for attaching the papillary muscles, to create less trauma to the delicate myocardium of the papillary muscles and to distribute tension more evenly over the entire surface of the papillary muscles.

A prosthetic ring is used systematically in all patients.3 The size of the ring is based on the measurement of the anterior leaflet of the homograft. The advantages of the ring annuloplasty include precise adaptation of the size of the annulus to the homograft, absorption by the semirigid ring some of the mechanical stress exerted by ventricular contraction that otherwise would be applied directly on the valvular suture line, and providing more surface for leaflet coaptation, thereby lowering the tension on the subvalvular apparatus. Early operations were performed using a Carpentier classic ring. A few operations using the flexible Duran ring resulted in less competent valves. Today, the Carpentier Physio® ring is used to remodel the shape of the mitral valve annulus; this device seems to be well suited for this operation.

REFERENCES


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