Transatrial Approach to Total Correction of Tetralogy of Fallot

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TOTAL CORRECTION of the tetralogy of Fallot can be made without coronary arterial division, ventriculotomy, or external enlargement of the pulmonary outflow tract. This is accomplished by a method which has evolved as an extension of the transatrial approach to closure of isolated ventricular septal defects. The following is a presentation of this method.

Method

The heart and great vessels are exposed through a median sternotomy incision. Arterial and venae caval cannulations are performed. The venae caval cannulas are inserted near the interatrial groove to avoid complication in making and closing the atrial incision (fig. 1a). High flow perfusion with mild hypothermia is used. Cardiac arrest is essential for accurate execution of this method. It is obtained by local hypothermia with saline ice. Left-heart decompression is maintained during the operative procedure and until cardiac resuscitation is complete.

After cardiopulmonary bypass is stabilized, the ascending aorta is cross clamped, and cardiac arrest is produced. An anteroposterior incision is made in the right atrium parallel to the right atrioventricular groove (fig. 1a). This incision is made as near the groove as possible. Enough atrial wall is left inferiorly to allow resuturing of the incision without injuring the right coronary artery. It is extended from the inferior vena cava anteriorly to and partially around the base of the atrial appendage. It is necessary for it to be made long enough to completely expose the tricuspid valve area with minimal retraction. Traction sutures are placed around the margins of the atriotomy, and its inferior rim is retracted inferiorly and to the patient's left. This brings the tricuspid valve clearly into view and into an almost horizontal position (fig. 1b). A small stab wound is made through a muscular portion of the atrial septum, and an appropriate drainage catheter is inserted into the left ventricle via the mitral valve for decompression. This catheter is brought out through the tip of the atrial appendage and suction is applied. Careful assessment of the pathological anatomy is made as the operation proceeds.

The septal leaflet of the tricuspid valve is made taut by grasping its free edge with atraumatic forceps, and it is detached circumferentially approximately 5 mm from the annulus. This incision is started with a small knife blade and is completed with small curved dissecting scissors. It may be extended into the base of either the anterior or posterior leaflet if additional exposure is necessary. This is most often required anteriorly, and a 1- to 2-cm. extension is usually adequate. The subsequent valvular repair will not be complicated by this extension, since there is a circular cuff of valvular tissue which is not separated by the commissures and the leaflets will remain attached to each other. By pushing the detached leaflet down into the right ventricle and gently retracting the tricuspid annulus, the right ventricular aspect of the pulmonary outflow tract and the ventricular septal defect are exposed (fig. 1c). The pulmonary valve and arterial end of the outflow tract are exposed through a supravalvular transverse arteriotomy. The outflow tract can then be evaluated as an intact tubular structure and is enlarged prior to closure of the ventricular septal defect.

Resection of the infundibulum is begun by grasping the point of maximum obstruction with forceps and excising all dense fibrous connective tissue and as much of the hypertrophied cardiac muscle in this area as possible (fig. 1d). This excision is made around the entire circumference of the pulmonary outflow tract, with care being taken not to produce excessive thinning of the septum or anterior myocardial wall. Thick muscular trabeculations are often present anteriorly. They occur just above the opening of the infundibulum, run transversely across the outflow tract, and play a significant role in systolic accentuation of the obstruction. These must be excised.

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Figure 1

Salient steps in operative procedure. a. Illustrates site of atriotomy. Note placement of caval cannulas. b. Tricuspid valve is exposed and septal leaflet incision is outlined. c. Exposure attained through valvular incision. d. Beginning removal of infundibular stenosis. e. Retrograde displacement of outflow tract for evaluation and relief of high infundibular obstruction. f. Closure of ventricular septal defect nearing completion. g and h. Tricuspid valve after repair with interrupted and continuous sutures.
After the resection has progressed to this point, the pulmonary valve is exposed again. Any back bleeding from the pulmonary artery can be controlled by a clamp placed distal to the arteriotomy. Feeling the valve through the right ventricular outlet may give an impression of annular constriction; however, in many instances, this represents an abnormality of the valve, and the opening can be made considerably larger by valvuloplasty. This is done by carefully dividing the commissures from above. The surgeon's left index finger is then inserted through the pulmonary valve into the ventricular outflow tract. The entire outflow tract is displaced in a retrograde direction for completion of the infundibular resection through the right atrium. The distance from the infundibular opening to the pulmonary valve is rarely over 2 to 3 cm., and this displacement is not difficult. When the outflow tract is longer than this, there is almost always an infundibular chamber which makes the operation easier, since the stenosis is localized and easily exposed. The residual thickness of the infundibular walls is constantly determined, and the resection continues around the intracardiac finger until the maximal possible size is attained. As the opening enlarges, the pulmonary valve is gradually displaced inferiorly, and any subvalvular component of the obstruction is relieved (fig. 1e). The final size of the outflow tract is readily determined with the ventricle intact, and when it seems adequate, the ventricular septal defect is closed.

Accurate exposure and closure of the defect are accomplished in a fashion similar to that for isolated ventricular septal defect (fig. 1f). The defect is closed by direct suture or with a synthetic fiber-patch. Direct suture is the method of choice, if feasible. Multiple interrupted mattress and simple sutures are used. The mattress sutures are buttressed with small Teflon pledgets. Initial placement of the sutures is made in the rim of the defect near the atrioventricular conduction bundle. This makes accurate suture placement easier in this critical area. After one or two of these sutures are placed, the remainder of the closure is started at the opposite end of the defect. All remaining sutures are placed before any are tied. The leaflets of the aortic valve are exposed well through this approach, and there is little danger of injuring them if reasonable care is taken during suture placement in the superior rim of the defect.

Repair of the tricuspid valve is made with interrupted and continuous 4-0 sutures (fig. 1g and h). Five to six interrupted sutures are placed to return the valve cuff to its normal position and to prevent the production of folds by the continuous suture. The latter suture strengthens the repair and assures competency of the suture line. The arteriotomy and pulmonary arteriotomy are closed, and coronary arterial blood flow is restored. If a normal rhythm does not return spontaneously with cardiac rewarmlng, the heart is defibrillated electrically after several minutes of vigorous fibrillation. Total body perfusion and left ventricular decompression are maintained until maximal cardiac recovery has occurred. The catheter is then removed from the left ventricle, the venae caval cannulas withdrawn into the atrium, and the bypass is stopped. After adequate blood volume and pressure are restored, the cannulas are removed and the vessels are repaired. Immediate cardiac chamber and great vessel pressure measurements are made with concomitant monitoring of blood flow.

**Operative Findings and Results**

This transatrial approach has been used in 10 consecutive patients with tetralogy of Fallot. All of these patients had equal ventricular pressures prior to the repair. Cyanosis varied from mild and intermittent to severe. Two patients had required systemic to pulmonary arterial shunts in infancy. Infundibular and valvular stenosis was present in all of the patients. The infundibular stenosis varied from diaphragmatic, with an associated infundibular chamber, to diffuse, with extension to the pulmonary valve annulus. Valvular stenosis varied from moderate to severe. The ventricular septal defect approximated aortic size in each patient and was just inferior to the aortic valve, posterior to the supraventricular crest, and superior to the papillary muscle of the conus. It was either partially or totally covered by the septal leaflet of the tricuspid valve.

The pulmonary outflow tract was exposed without difficulty and adequate relief of the obstruction was attained in each instance. This was determined by direct pressure measurements when pulmonary arterial blood flow was within the normal range. Right ventricular pressure was less than 50 per cent of the left ventricular pressure in all patients. One patient with previously severe infundibular stenosis had a right ventricular pressure of 25/0 mm. Hg. Right ventricular to pulmonary arterial pressure gradients varied from 0 to 45 mm. Hg. Ideal exposure of the ventricular...
septal defect has been attained in each patient and direct closure effected with ease.

Perfusion time varied from 45 to 90 minutes, and averaged 60 minutes. Postoperative tricuspid valvular function has been normal. Except for two patients who developed postoperative cardiac arrhythmias, central venous pressure has been low, and there has been no other evidence of right ventricular failure. Myocardial ischemia has not been demonstrated by electrocardiography, and the "low cardiac output syndrome" has not occurred.

Comment

The transventricular approach to total correction of the tetralogy of Fallot, as first described by Lillehei and associates, is well known, and extensive application has proved its efficacy. There are, however, certain inherent disadvantages associated with this method. These have contributed to operative morbidity and mortality in many instances.

Efforts to circumvent these disadvantages have led to the development of the transatrial approach presented here. Complete atresia of the pulmonary outflow tract will obviously require modifications of the method. However, the intact right ventricle should tolerate considerably greater right ventricular to pulmonary arterial pressure gradients, and may allow application of this method to patients with a much smaller outflow tract than has been encountered thus far.

Anatomical studies and the clinical experiences presented herein have led to the belief that most patients with tetralogy of Fallot may undergo complete correction by this method. Many of these patients will prove no more difficult to manage than those with simple, isolated, ventricular septal defect. Experience will be extended as opportunity permits. Others are encouraged to apply and evaluate the method.

Summary

A transatrial approach to total correction of the tetralogy of Fallot is presented which utilizes: (1) anteroposterior incision of the right atrium near the right atrioventricular groove; (2) circumferential detachment of the septal leaflet of the tricuspid valve near the annulus; (3) pulmonary arteriotomy with valvuloplasty, if necessary; (4) retrograde displacement and resection of the stenosed infundibulum through the right atrium; (5) closure of the ventricular septal defect; (6) closure of the incision in the tricuspid valve; and (7) closure of the atriotomy.

Clinical application to 10 consecutive patients, varying from acyanotic to severely cyanotic, has confirmed the advantages and simplicity of this method. Coronary arterial division, ventriculotomy, and external enlargement of the pulmonary outflow tract have been unnecessary. Relief of pulmonary stenosis has been adequate in each instance. The ventricular septal defect has been well exposed in each patient, and its closure has presented no special problem.

There have been no complications associated with the method, and postoperative cardiac function has been good. Operative as well as clinical features of the method are still under investigation; however, experience thus far has led to its establishment as a routine for total correction of the tetralogy of Fallot in this clinic.

References

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