

Congenital Surgery

Transatrial Repair of Tetralogy of Fallot

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The approach of avoiding or minimizing a right ventriculotomy during the repair of tetralogy of Fallot has been utilized for many years.^{1,2} As long-term sequelae have been studied, it has become apparent that right ventricular dysfunction, due at least in part to the right ventriculotomy used to close the ventricular septal defect (VSD) and relieve the outflow tract obstruction, has emerged as an important cause of late problems.³ The common practice of extensive resection of obstructing right ventricular muscle to properly repair tetralogy of Fallot was due, in part, to the earlier experience gained in older children in whom significant and long-standing right ventricular hypertrophy frequently mandated such an approach.⁴ However, as earlier repair before the occurrence of secondary hypertrophy became more commonplace, it was appreciated that right ventricular outflow tract obstruction could be adequately relieved solely by division of muscle bundles, thus avoiding muscle excision entirely. A long, right ventriculotomy placed merely to expose the VSD is unnecessary because a right atrial approach through the tricuspid valve provides excellent exposure. Therefore, the distal right ventricular infundibulum needs only to be opened sufficiently to relieve pulmonary valve and infundibular hypoplasia when the anatomy dictates.

Transatrial repair of tetralogy of Fallot can be performed at any age, even in neonates. Elective repair is generally recommended between 3 and 6 months of life. The advantages of early repair are now generally well accepted and include: (1) relief of cyanosis, (2) avoidance of shunt complications, (3) decreased incidence of late dysrhythmias, (4) need for little

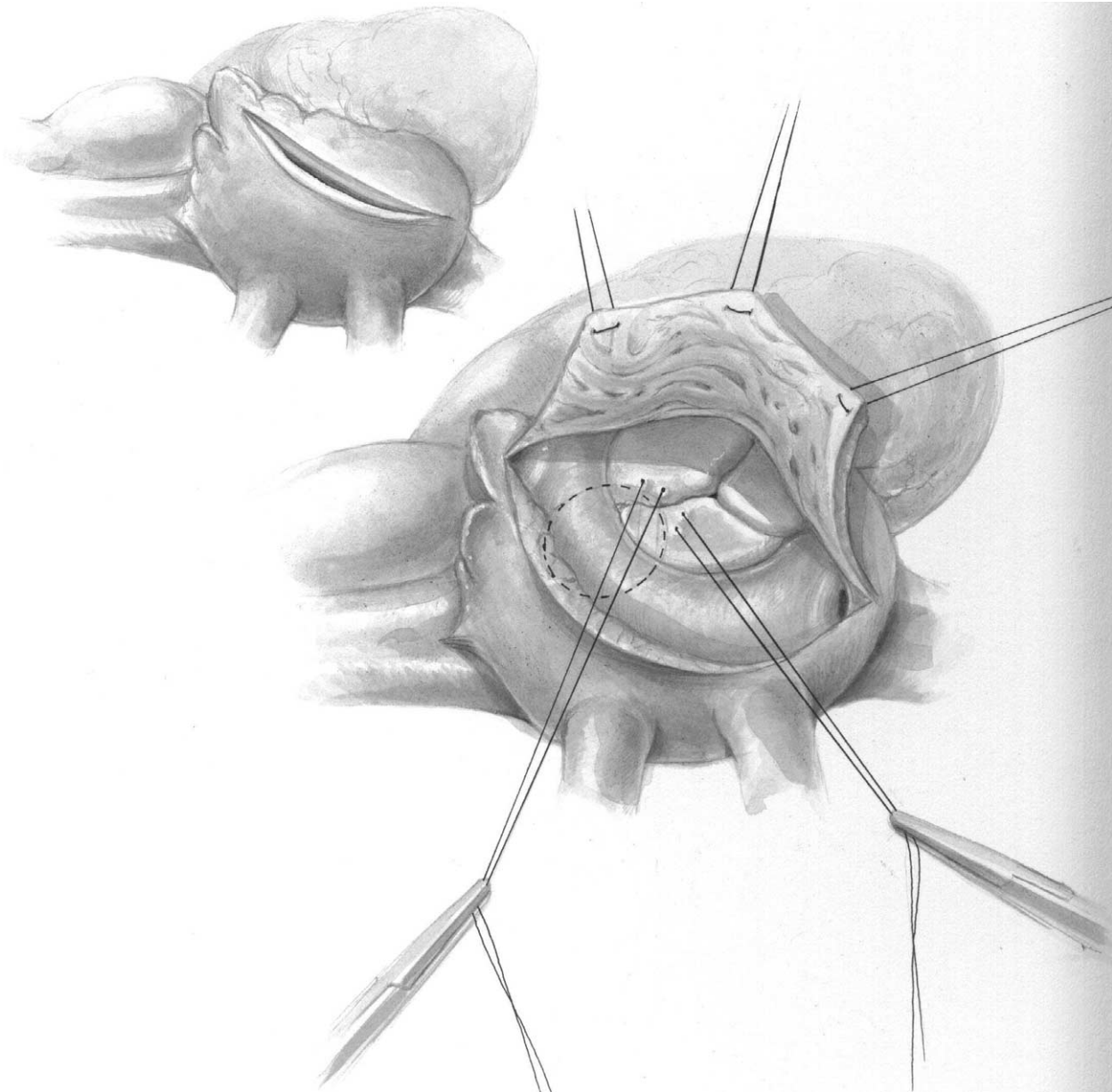
or no right ventricular muscle resection, (5) improved late left ventricular function, and (6) socioeconomic factors.

Standard cardiopulmonary bypass with moderate hypothermia and cold blood cardioplegia administration are utilized. Circulatory arrest is unnecessary, even in the neonate. Through a right atriotomy, exposure through the tricuspid valve affords an excellent view of the VSD and right ventricular outflow tract anatomy. The malalignment VSD is identified and the anterior limb of the septal band is a key anatomic structure to improve exposure of the distal infundibulum. It is important to remember that the usual spatial orientation of right-left and anterior-posterior is distorted by the rotation of the heart necessary to view the right ventricular outflow tract through the tricuspid valve. Obstructing muscle bundles along the parietal and septal surfaces are identified and divided up to the level of the pulmonary valve. It is essential to visualize the pulmonary valve annulus to be certain that all potentially obstructing muscle bundles have been identified and divided. Resection of muscle is virtually never required. The VSD is then closed in the usual fashion. Once the muscle bundles along the anterior limb of the septal (parietal) band are divided, VSD closure is facilitated because the superior portion of the defect is much more mobile, thus bringing it into the view of the surgeon easier. The pulmonary valve and its annulus are evaluated in the usual fashion and a transannular patch placed when the annulus is judged to be inadequate, generally correlating to a Z-score equal to or less than -3 . However, in these instances, the incision on the right ventricular infundibulum can often be minimized to between 5 mm and 10 mm because the rest of the right ventricular outflow tract obstruction has been relieved transatrially. An incision of this length is inadequate to expose the VSD, underscoring the unnecessarily lengthy incisions previously used solely for VSD closure.

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Operative Techniques



Figures 1 and 2 Standard cardiopulmonary bypass with direct bicaval cannulation is achieved, even in the neonate, at a systemic temperature of 28°C to 32°C (cannulas removed for clarity). A vent is placed through the right superior pulmonary vein and cold blood cardioplegia administered after aortic cross clamping. A right atriotomy is made parallel and *close to* the right atrioventricular groove. Placing the incision in this location assists in the exposure by elevating the anterior wall of the right ventricle and tricuspid valve with the stay sutures inserted along the atriotomy. The ventricular septal defect is visible behind the anterior leaflet of the tricuspid valve. Traction sutures are placed in the anterior and septal leaflets of the tricuspid valve. In the neonate, a patent foramen ovale is generally left open, but is closed in older infants.

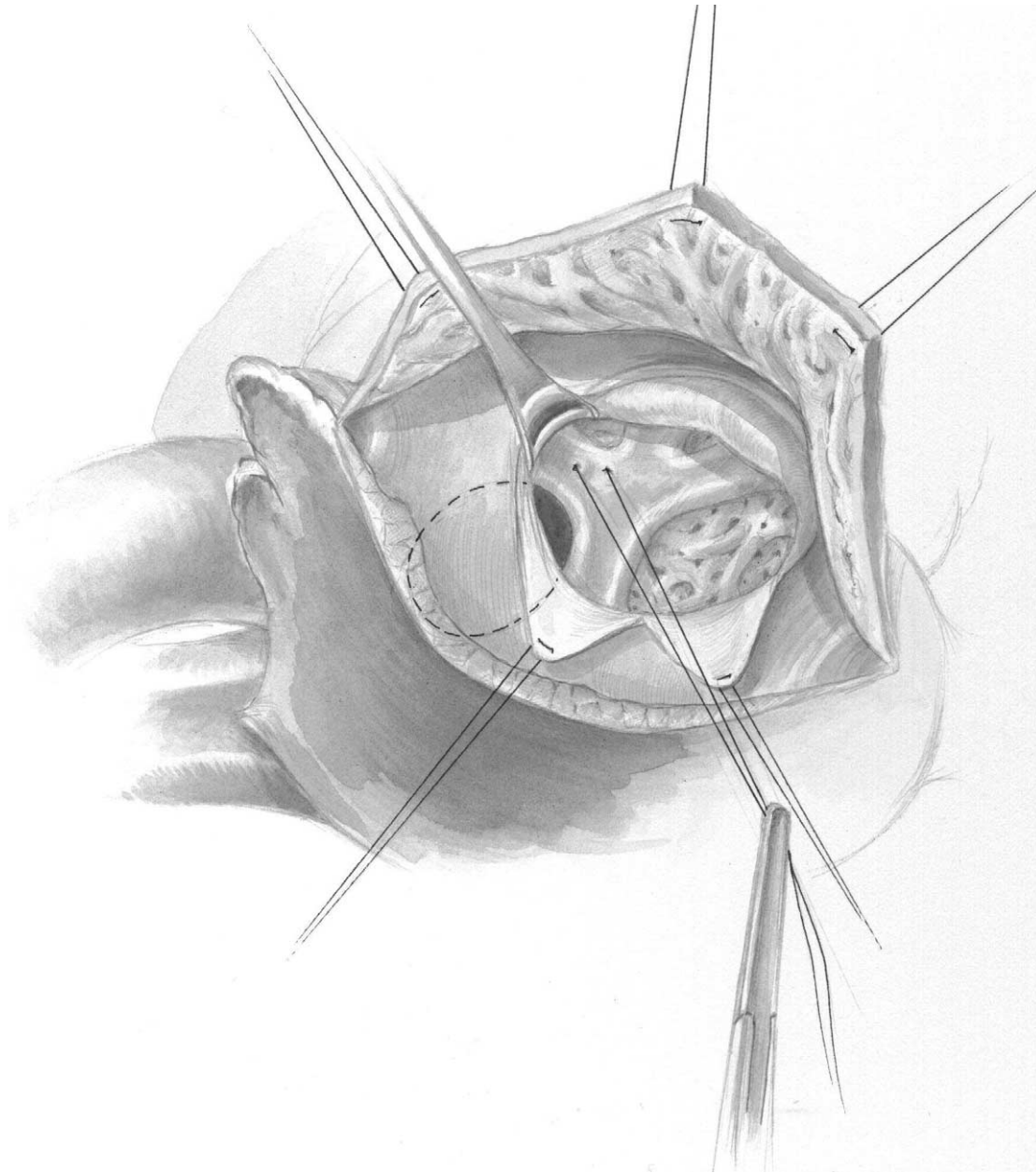


Figure 3 The traction sutures placed on the anterior and septal leaflets of the tricuspid valve are essential in providing exposure with minimal retractors in the field. Each suture is retracted directly toward the surgeon, which pulls the septum and VSD into view. A small right-angle retractor is then placed under the anterior leaflet and pulled superiorly. The anterior limb of the septal band is identified. A traction suture placed here can help in the visualization of the outflow tract and help in keeping the surgeon's orientation. The traction suture placed in the anterior limb of the septal band, which marks the anterior edge of the VSD, can be very helpful in maintaining orientation and exposing the distal outflow tract. Anterior and superior to this point is the pathway to the pulmonary valve, and the marking suture serves as a useful frame of reference to avoid an incision into the VSD itself.

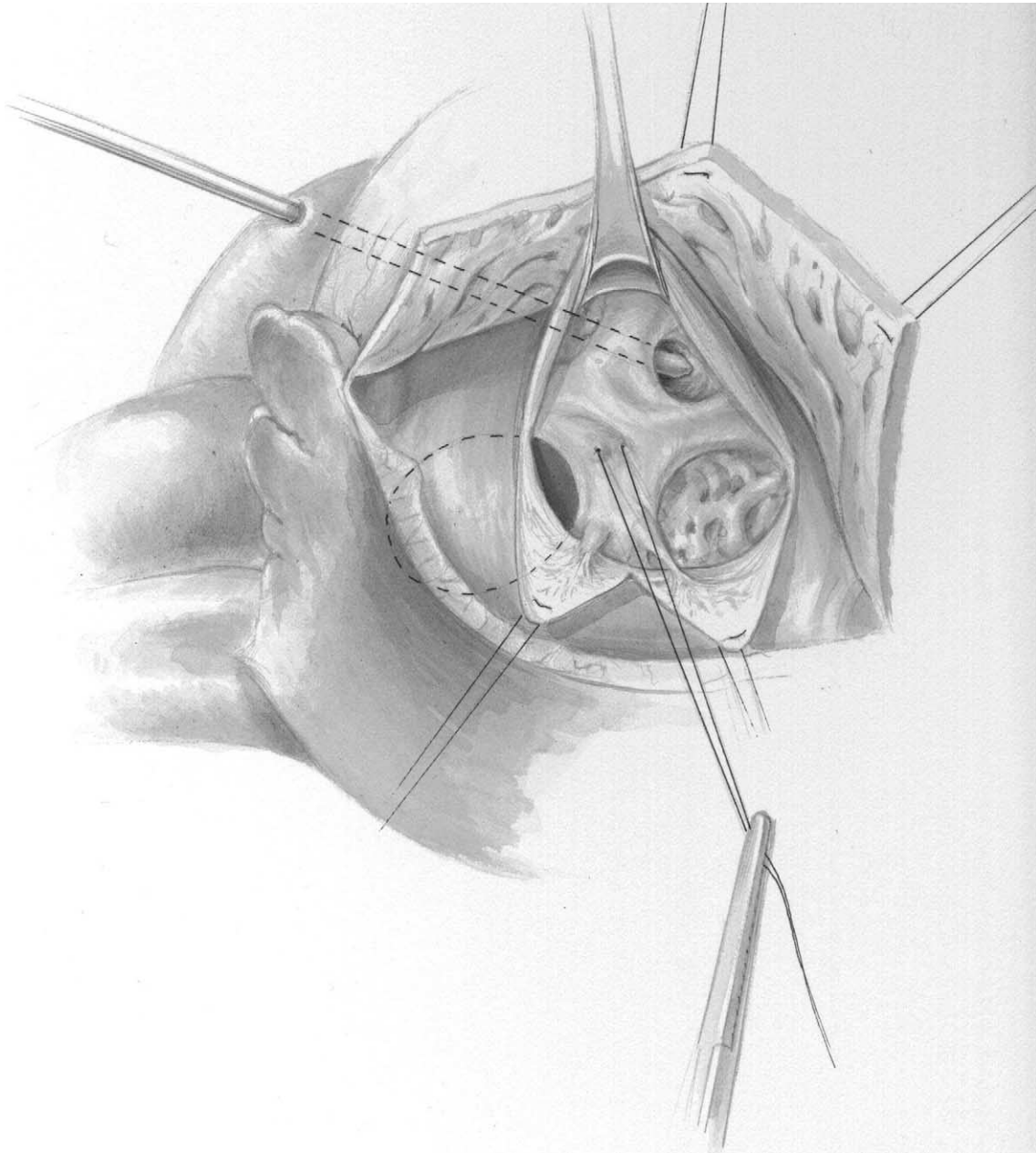


Figure 4 The malalignment VSD is exposed, but relief of the right ventricular outflow tract obstruction is performed first. In some cases, a small calibrated dilator can be passed retrograde through the pulmonary valve to assist in exposure. Although not generally necessary, this maneuver has been found to be helpful when first attempting transatrial repairs, particularly in very small patients.

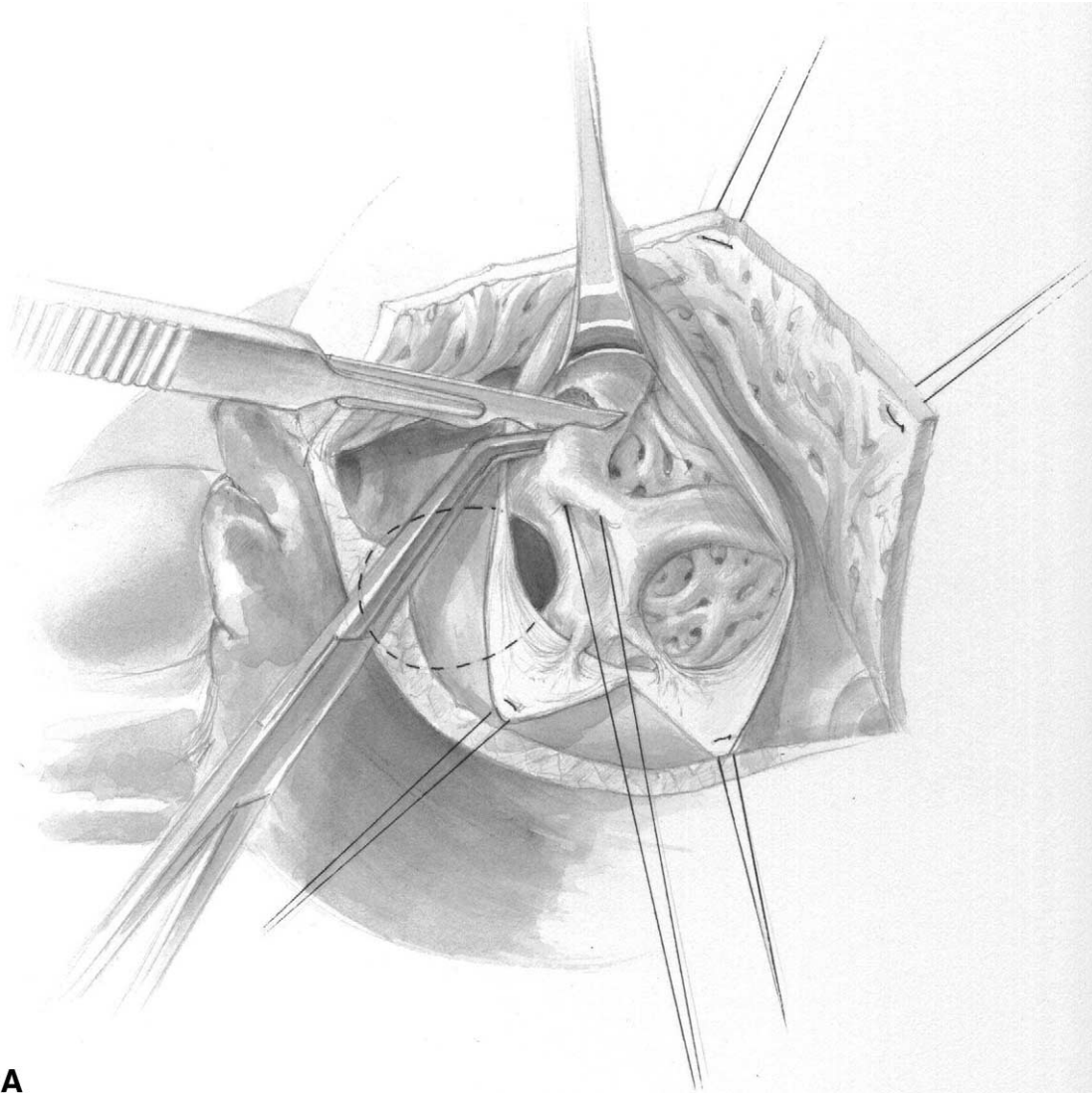
**A**

Figure 5 (A) A right angle clamp is now placed around the right ventricular outflow tract muscle bundles until the pulmonary valve can be clearly seen. This is done on both the parietal and septal surfaces.

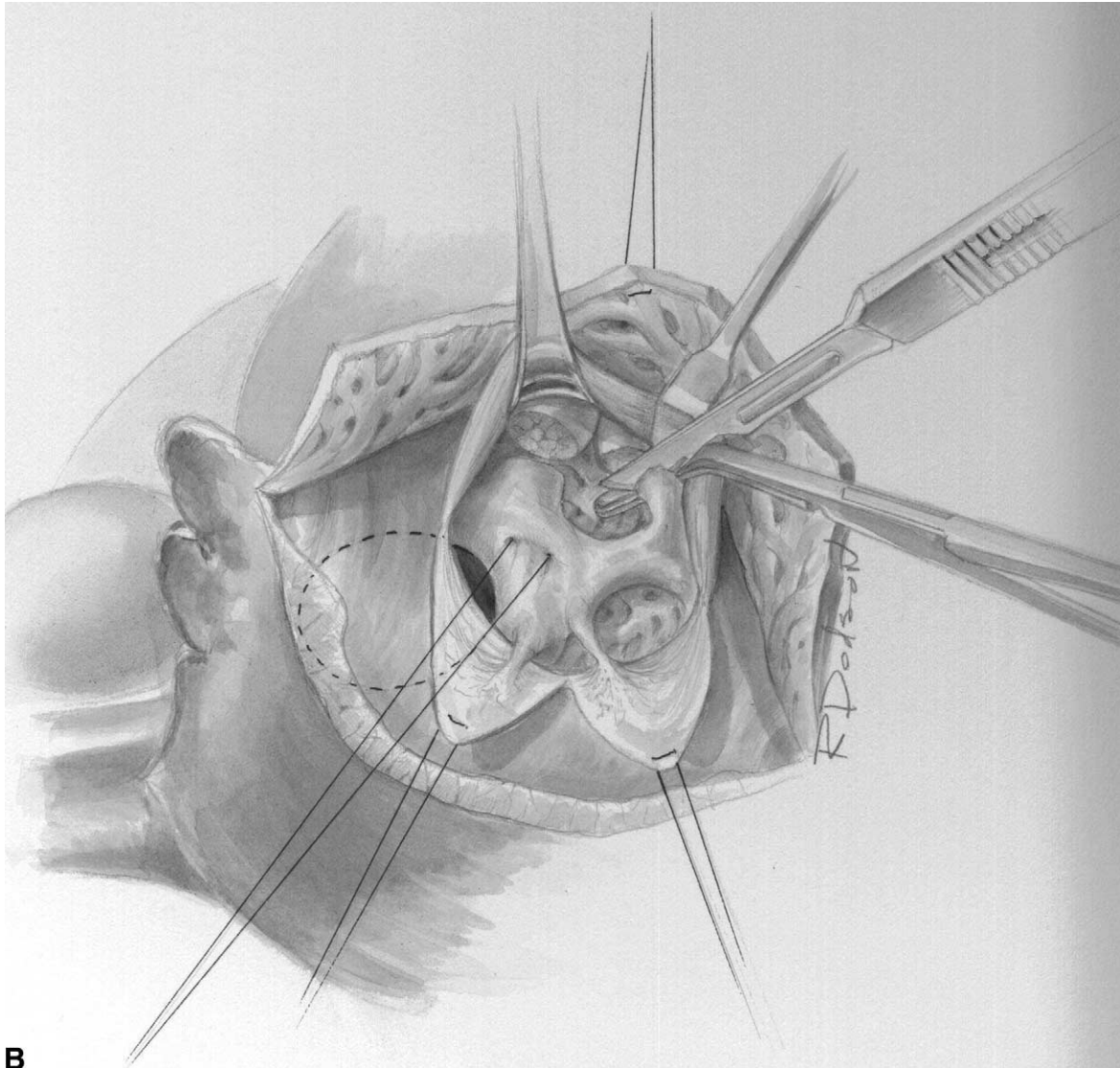


Figure 5 (B) Gentle probing with the clamp is important to avoid creating injury to the septum. In neonates and infants, this is generally easy to do as there is little secondary hypertrophy and the muscle bundles appear as “discrete” bands, which can be encircled for division. Resection is unnecessary as the outflow tract will expand sufficiently. It is important to realize that, although uncommon, some patients will not be suitable for transatrial muscle division secondary to hypoplasia of the right ventricular outflow tract. In such cases, an outflow tract patch will be required to enlarge the area of hypoplasia.

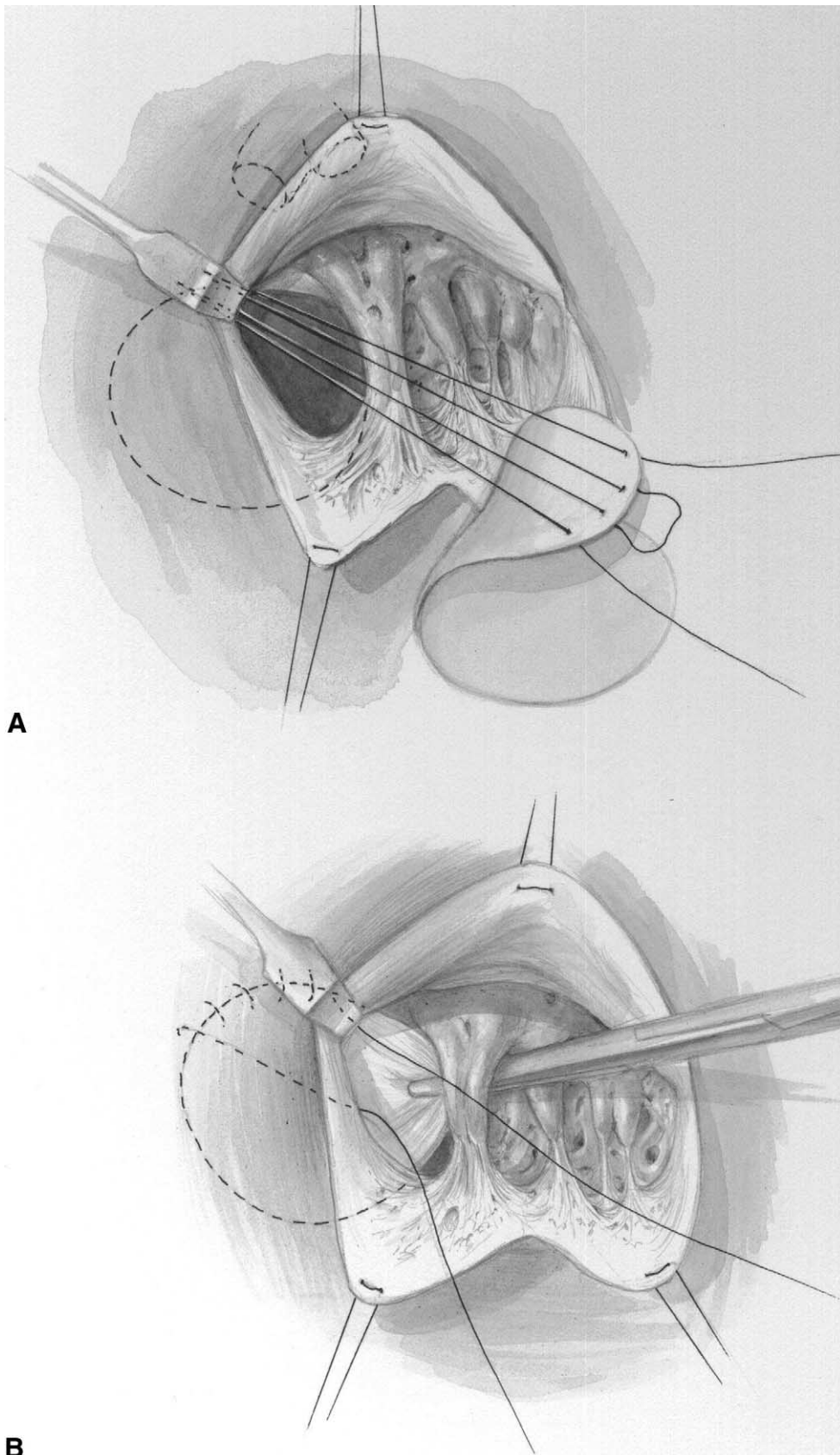


Figure 6 (A and B) Following relief of right ventricular outflow obstruction, the VSD is closed. A continuous suture technique is preferred, beginning at the juncture between the anterior and posterior limbs of the septal band. The first arm of the suture is placed along the anterior limb and around the annulus of the aortic valve. The latter is exposed more easily after the muscle bundles are divided. This suture passes into the right atrium where the aortic and tricuspid valves come together at the ventriculoinfundibular fold.

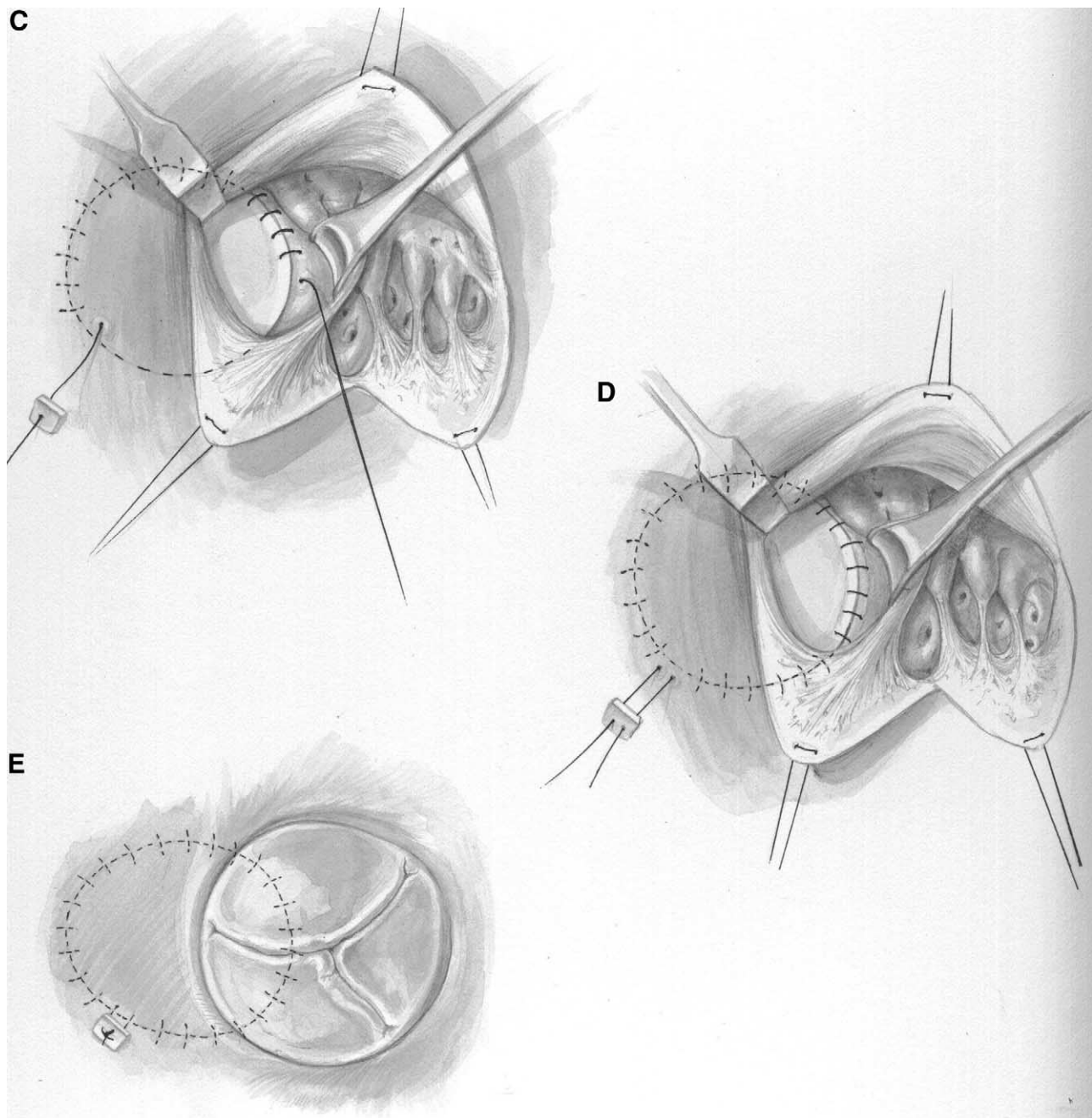


Figure 6 (C-E) The opposite needle is then used to anchor the patch along the inferior limb of the septal band and along the septal leaflet of the tricuspid valve in the standard fashion using the usual techniques to avoid injury to the conduction system. It is often necessary to weave the suture under the chordal attachments of the tricuspid valve to avoid distortion. The two ends of the suture are tied over a small pericardial pledget. It is important to test the tricuspid valve with saline to ensure that the valve is fully competent. A suture placed at the anterosseptal commissure of the valve is occasionally needed to reinforce this area.

Conclusions

Late studies have clearly demonstrated an association between a right ventriculotomy and important adverse sequelae following tetralogy repair, particularly in the presence of pulmonary insufficiency. Other studies have shown a benefit when avoiding or minimizing a right ventriculotomy during the repair. Exercise endurance time, right ventricular function, end-diastolic dimension, and QRS width have all been shown to be improved.⁵ Further-

more, preservation of right ventricular function, particularly of the distal infundibulum, may minimize the deleterious effect of pulmonary regurgitation, which will still be present in a significant number of patients due to hypoplasia of the pulmonary valve annulus. Other late benefits include the avoidance of coronary artery injury as well as the reduction of right ventricular fibrosis and ventricular dysrhythmias.

Although transatrial repair is feasible at any age, it is preferable to perform the repair before secondary hyper-

trophy makes simple division of outflow tract muscle bundles unlikely to be successful in relieving obstruction.⁶ The exact age when this transition occurs is not known, but elective repair within the first six months of life is recommended. Dividing the right ventricular outflow tract muscle bundles with a right-angle clamp will satisfactorily relieve obstruction in nearly all patients and removal or excision of muscle is unnecessary. Transannular patches, when needed for hypoplasia of the pulmonary valve annulus, can then be limited to only the very distal outflow tract because exposure of the more proximal part is not needed. In fact, it is our experience that neither VSD closure nor muscle division can be satisfactorily exposed through the very short ventricular excision placed for a transannular patch.⁷ Preservation of the pulmonary valve, extension of the patch distally to relieve branch stenoses, or insertion of a monocusp valve can be used as dictated by the individual anatomy or surgical preference.

References

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