

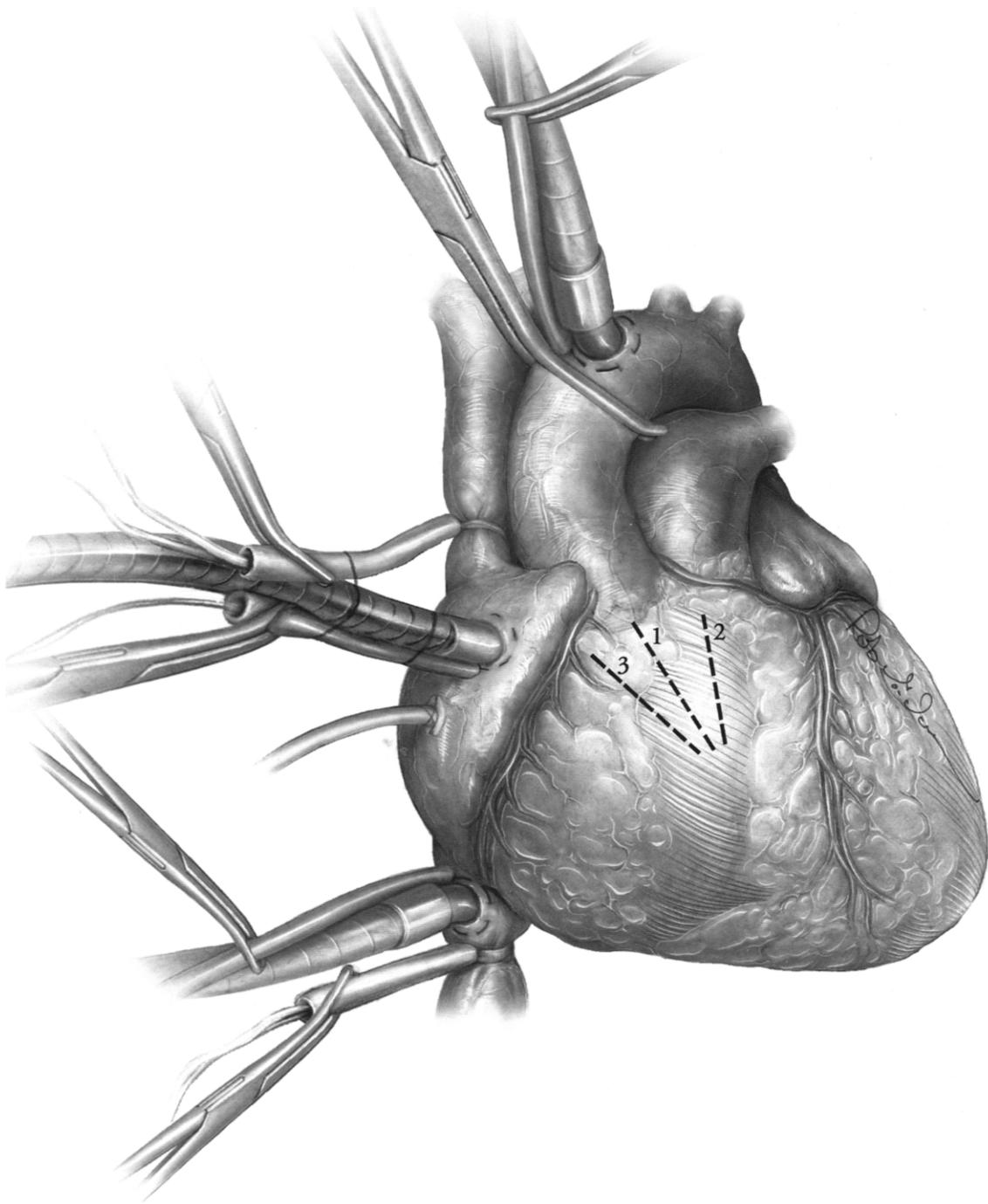
Réparation à l'Etage Ventriculaire (REV Procedure): Not a Rastelli Procedure Without Conduit

Yves Lecompte and Pascal Vouhé

Since 1980, we have been using a procedure, which we call Réparation à l'Etage Ventriculaire ([REV] procedure), for the repair of transposition of the great arteries associated with ventricular septal defect (VSD) and pulmonary outflow tract (POT) obstruction. The object of this procedure is to overcome some of the limitations and drawbacks of the Rastelli operation, which is the most common choice worldwide for this type of defect. One of these drawbacks is the use of a circular conduit for the repair of the POT. However, the most serious limitations of the Rastelli procedure relate to the construction of the left ventricle (LV) to aorta tunnel. The REV procedure allows some of the anatomic contraindications to biventricular repair to be overcome and, much more importantly, to decrease

the incidence of the late complications associated with classical repair (i.e., deterioration of LV function) and the development of subaortic stenosis.^{1,2} The final advantage of avoiding the use of a circular conduit for reconstructing the POT is, in our experience, of secondary importance. For this reason, the intracardiac step of the REV procedure will be described in great detail in this article. Although the REV procedure can be indicated in many types of anomalies of ventriculo-arterial connection, the description will be limited to the most frequent anatomy: "classical" transposition of the great arteries, with fibrous continuity between the atrioventricular valves and the pulmonary artery, and a well-developed subaortic infundibulum.

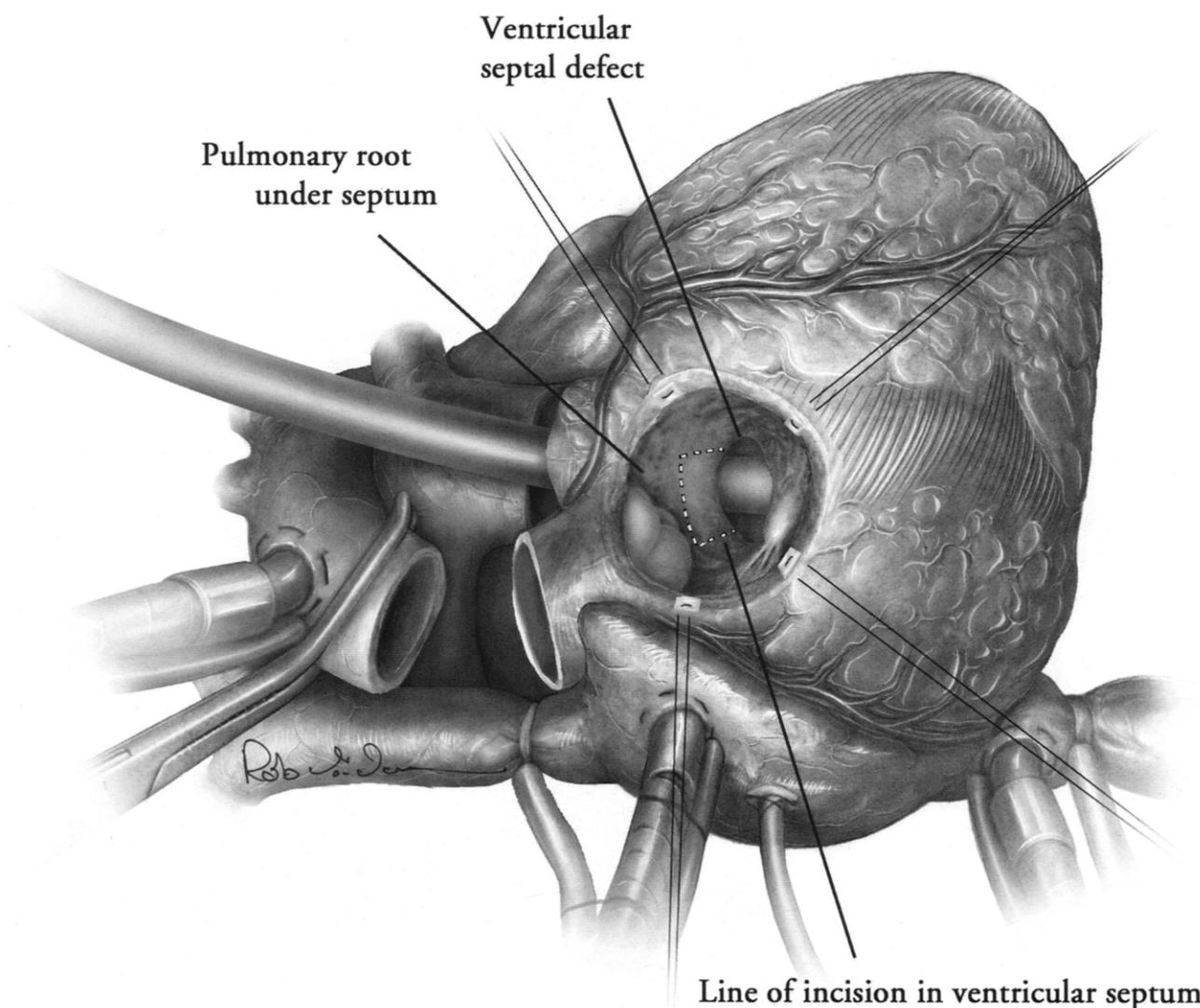
SURGICAL TECHNIQUE



I The procedure is performed through midline sternotomy, using conventional cardiopulmonary bypass with bicaval cannulation and a vent in the left atrium. Since 1995, we have performed all the procedures using normothermia and since 1999 we have used warm intermittent cardioplegia for myocardial protection. This cardioplegia is delivered every 10 to 15 minutes either in the aortic root or, while the aortic root is transected, directly in the coronary arteries.

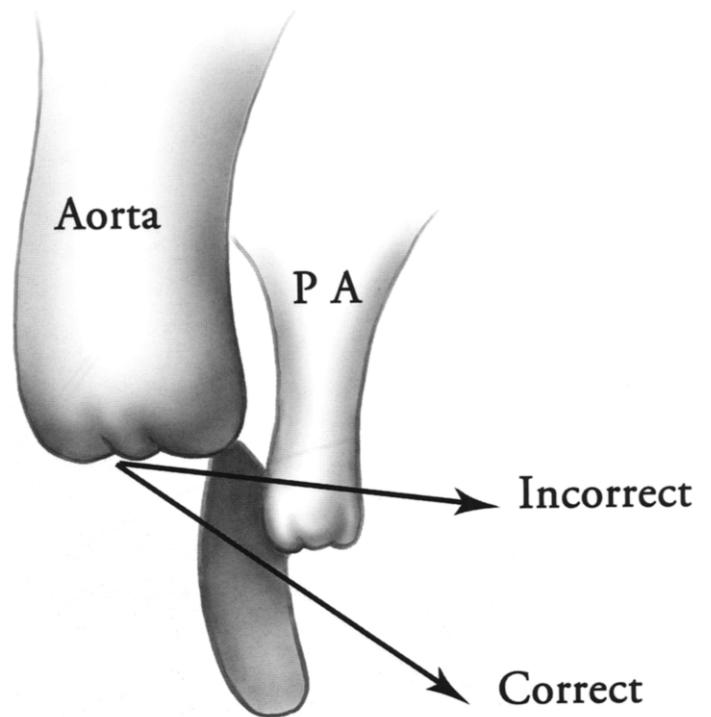
Before heparinization, the ascending aorta, the pulmonary trunk, and its branches are dissected out and care is taken to transect the pericardial attachments of all the vessels to facilitate their mobilization without traction. The ductus arteriosus or its remnants and the palliative aorticopulmonary shunts, when present, are transected (and not merely ligated) after initiation of the bypass. During the first infusion of cardioplegia, the right atrium is opened, and the atrial septal defect is closed either directly or with the use of a patch.

The right ventricle is then opened. The incision is generally made longitudinally on the anterior wall of the subaortic infundibulum. It should start from below because the aortic orifice is generally lower than expected. In some patients, the orientation of the incision has to be slightly modified because of the presence of a coronary artery or because of the planned repair of the POT. The pulmonary artery bifurcation is not placed anteriorly to the ascending aorta in all cases. Initially, when the great vessels are strictly side by side, it can be easier to leave the pulmonary trunk on the left side (more rarely on the right side) of the aorta. In such cases (1 of 5 of our patients), the decision has to be made at this point, and the direction of the ventricular incision should be so that it facilitates its reimplantation.

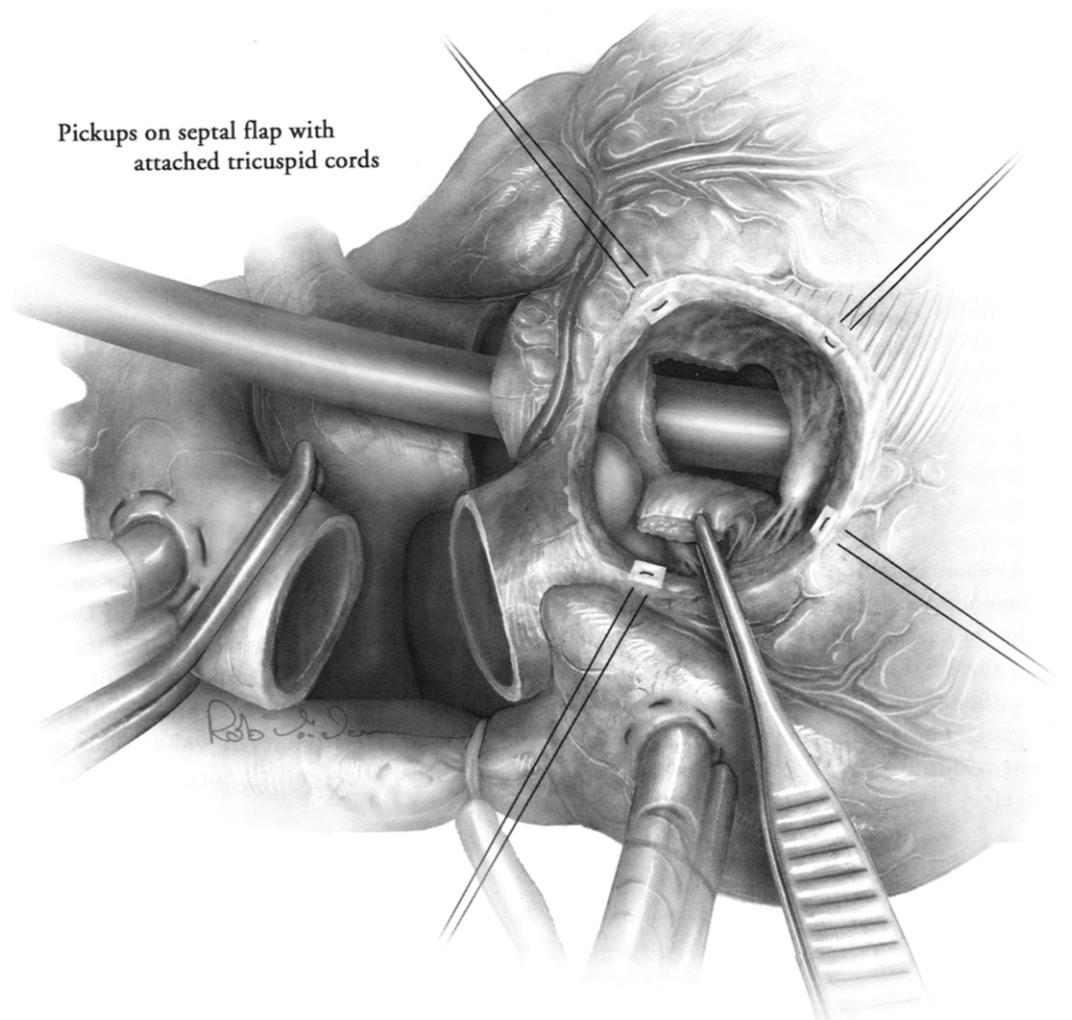


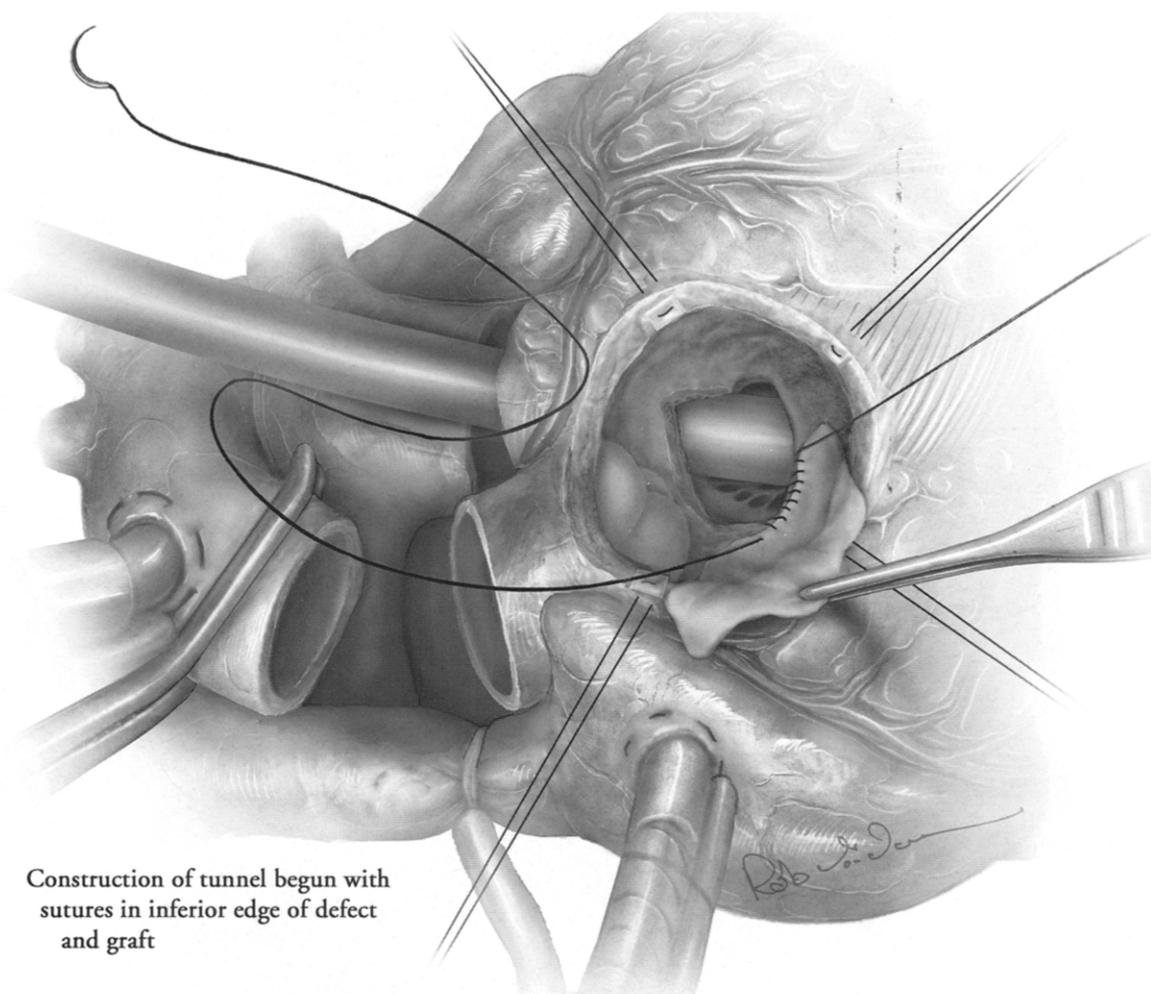
2 The anatomy of the defect is analyzed through the ventricular incision. The limits of the VSD, the position of both semilunar orifices, and the presence of tricuspid attachments in the projected path of the future intraventricular tunnel and/or on the infundibular septum are checked precisely. If the feasibility of the repair is confirmed, the great arteries are transected. When the pulmonary bifurcation is to be placed anterior to the aorta, the ascending aorta is first transected above the valvar commissures. In all cases, the pulmonary arterial trunk is transected at the level of the commissures or lower, leaving enough tissue to close the pulmonary orifice safely. When indicated, the pulmonary bifurcation, totally dissected free from any pericardial attachment, is placed anterior to the ascending aorta. The next step, which is the key point of the procedure, is the resection of the infundibular septum. The procedure is highly facilitated by the introduction of a Hegar dilator through the pulmonary orifice into the LV. This maneuver exposes the infundibular septum perfectly and, furthermore, protects the mitral valve. Three lines of incision are made to remove totally the part of the septum comprised between the VSD and the aortic orifice.

3 The subaortic line of incision must be slightly oblique because the pulmonary orifice is generally lower than the aortic one: An incision perpendicular to the plane of the septum may injure the pulmonary annulus or one of the coronary arteries. When this resection is correct, it *always* permits the construction of a large tunnel from the LV to the aorta, even if the VSD was initially restrictive. In general, it is pointless and may even be harmful to extend the resection anteriorly where important coronary arteries may be present.

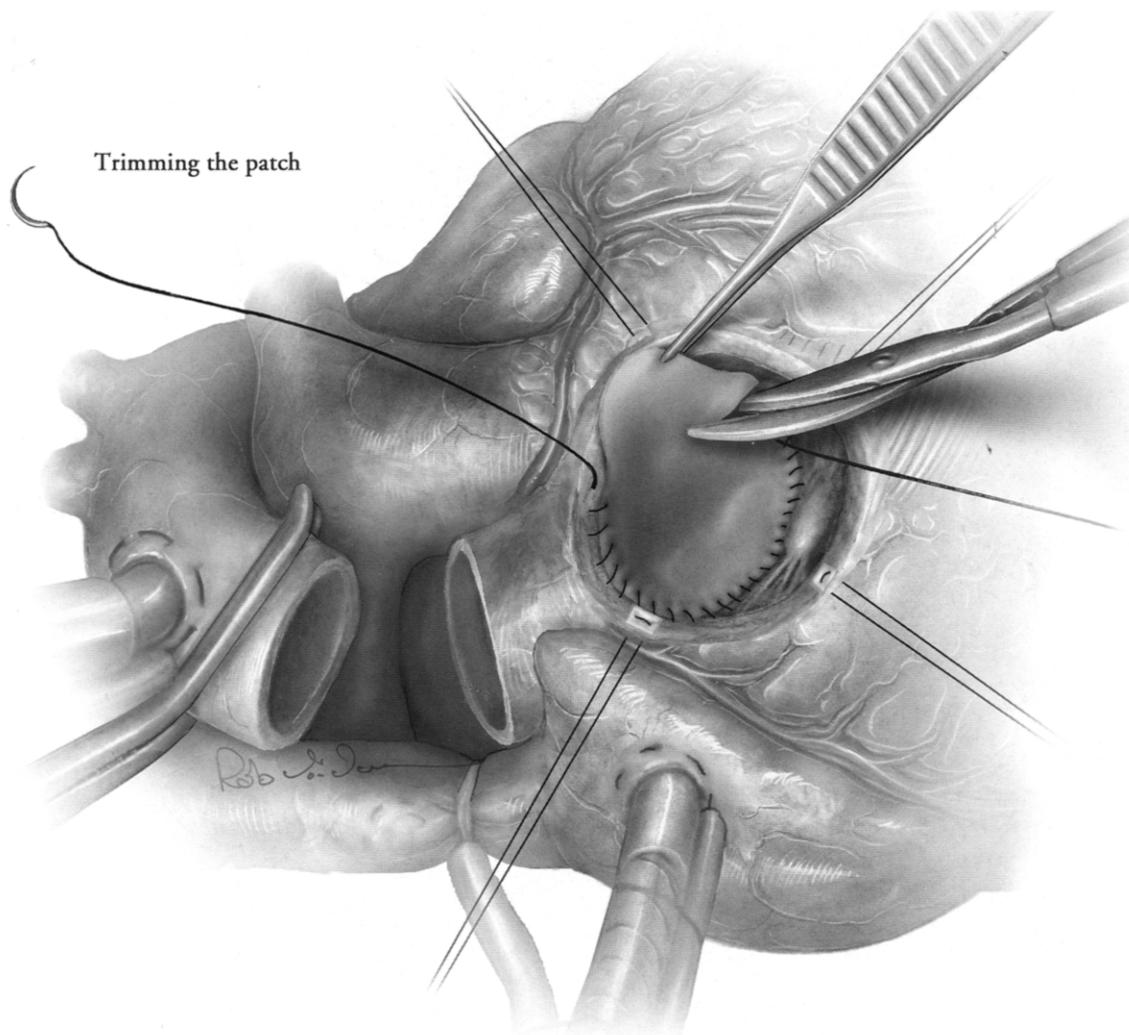


4 When there are insertions of the tricuspid valve into the infundibular septum, the technique has to be slightly modified. In such cases, the infundibular septum is not resected but mobilized. The incision is made anteriorly and then under the aortic valve, thus creating a septal flap with its tricuspid attachments. This flap is pulled posteriorly to permit the construction of the LV to aorta tunnel. It will be re-attached onto the intraventricular patch following the completion of its construction.

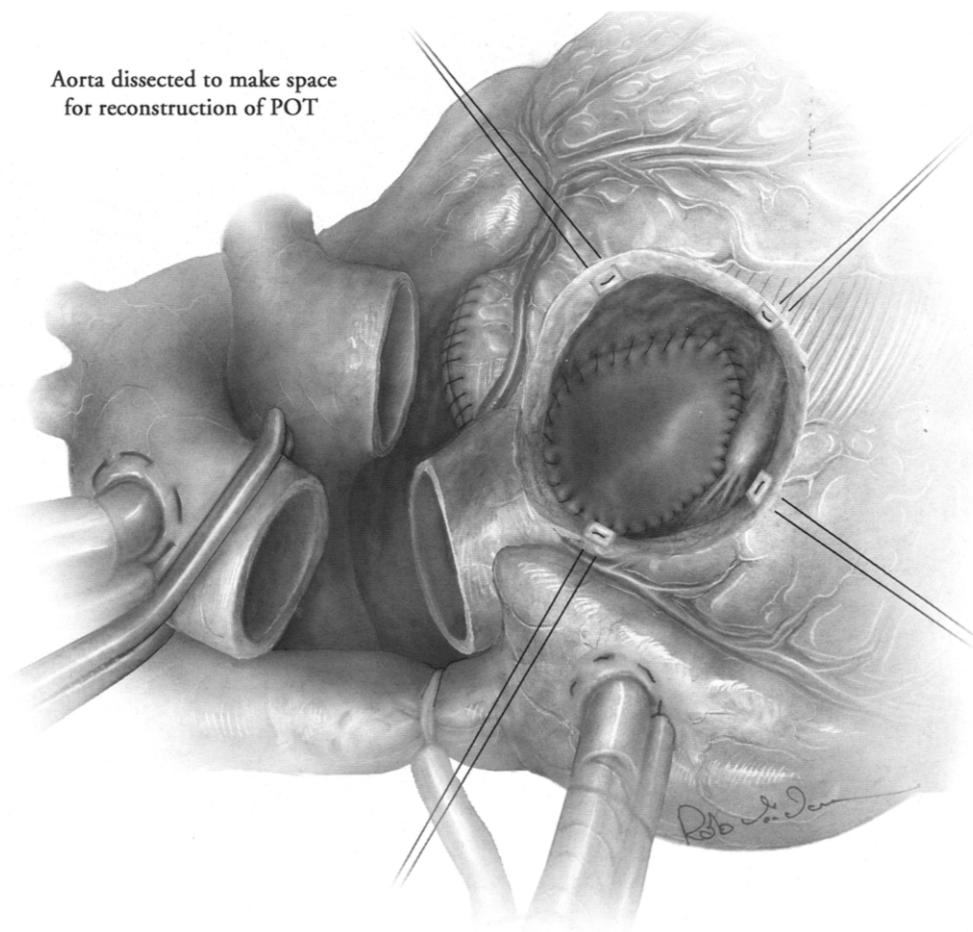




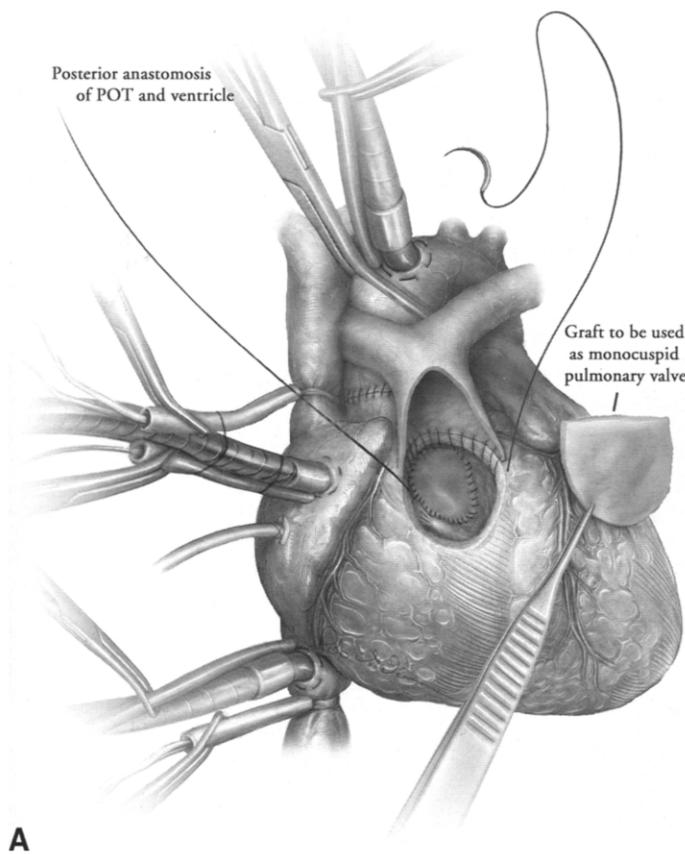
5 The construction of the intraventricular tunnel can then be started. One of the authors uses heterologous pericardium, the other one prefers a “sandwich” of heterologous pericardium (on the left side) and Dacron (Medox Medical Inc., Oakland, New Jersey) velour. Initially, the patch is cut in a circular fashion. The diameter is the distance between the most posterior part of the VSD and the most anterior point of the aortic annulus. The stitches are first placed on the inferior border of the VSD, either through the septal leaflet of the valve or on the muscular rim, which separates the defect from the valve when it is present. The suture line then runs towards the right part of the aortic valve. This region must be perfectly exposed to prevent residual VSD. It is often useful to push the transected ascending aorta towards the right ventricular cavity to attain this perfect exposure.



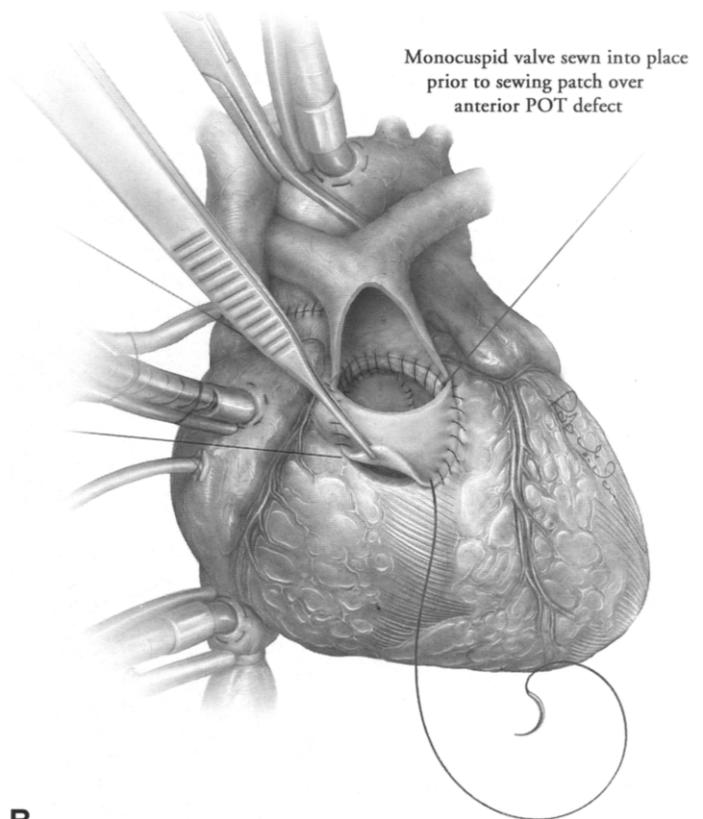
6 When the most anterior point of the aortic annulus is reached, the patch can be adjusted to its final size. The aim of this precise limitation of the size of the patch is to construct as flat and direct a tunnel as possible. Because the resection of the infundibular septum has created a large and straight communication between the ventricles, the size of the intraventricular tunnel will not depend on the size of the patch. Tailoring the patch “generously,” as suggested by so many investigators, is detrimental as well as pointless: (1) It does not prevent, as expected, the development of subaortic stenosis (in the authors’ opinion, it even increases this risk); (2) it is harmful for the left ventricular function (this patch acts like an aneurysm); and (3) it occupies space in the right ventricular cavity. The patch must be tailored to cover the anterior rim of the intraventricular defect without bulging. In most cases, one-third (or more) of the surface of the initial patch has to be removed. The anterior part of the patch can then be stitched.



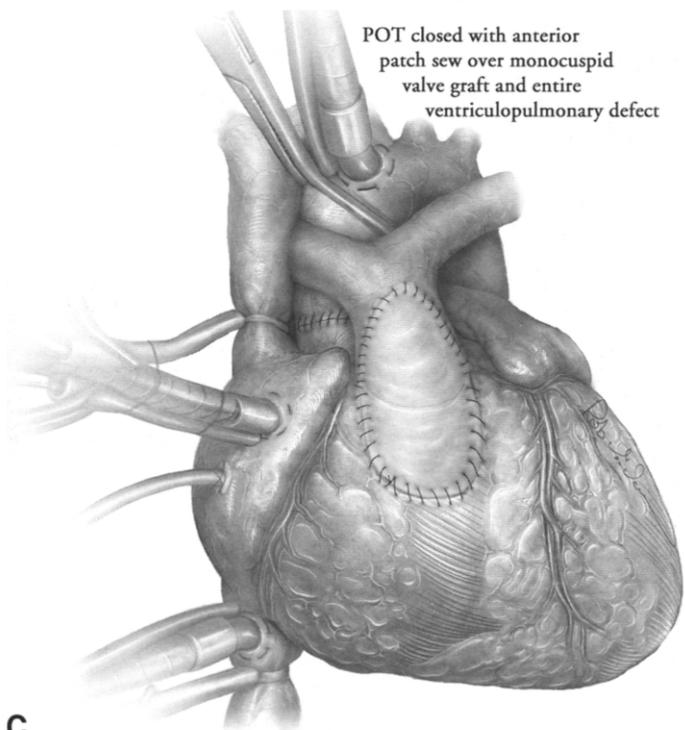
7 The pulmonary orifice is closed directly. Much attention must be paid to the coronary arteries, which run close to this orifice. It is useful after completing closure of the orifice to introduce gently an instrument into the coronary ostia to exclude the possibility of any injury or distortion of these arteries. When the pulmonary artery bifurcation is to be placed anterior to the aorta, it is mandatory to resect generously a large piece of ascending aorta. This procedure is aimed at creating a large space in the anterior mediastinum for the reconstruction of the POT. The aorta is then reconstructed.



A

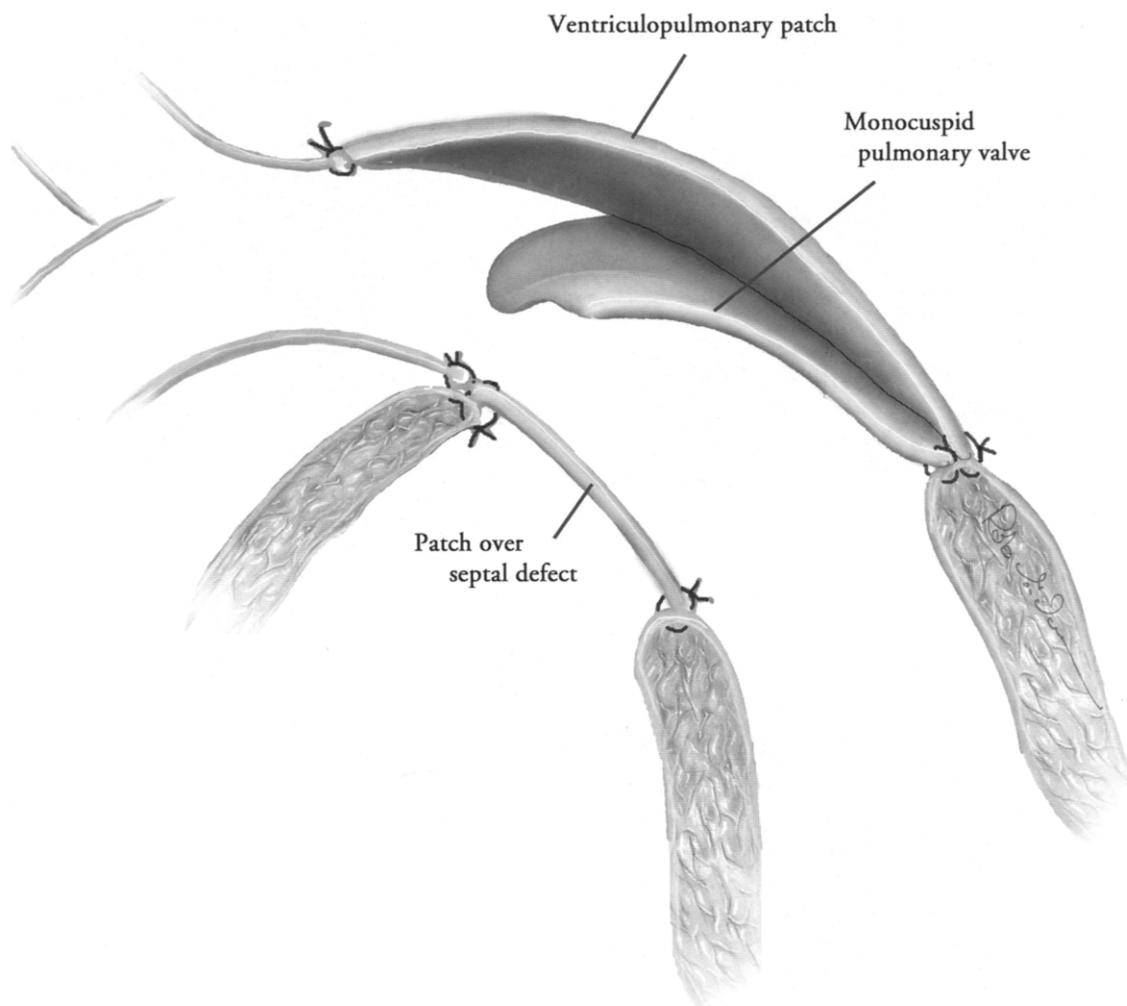


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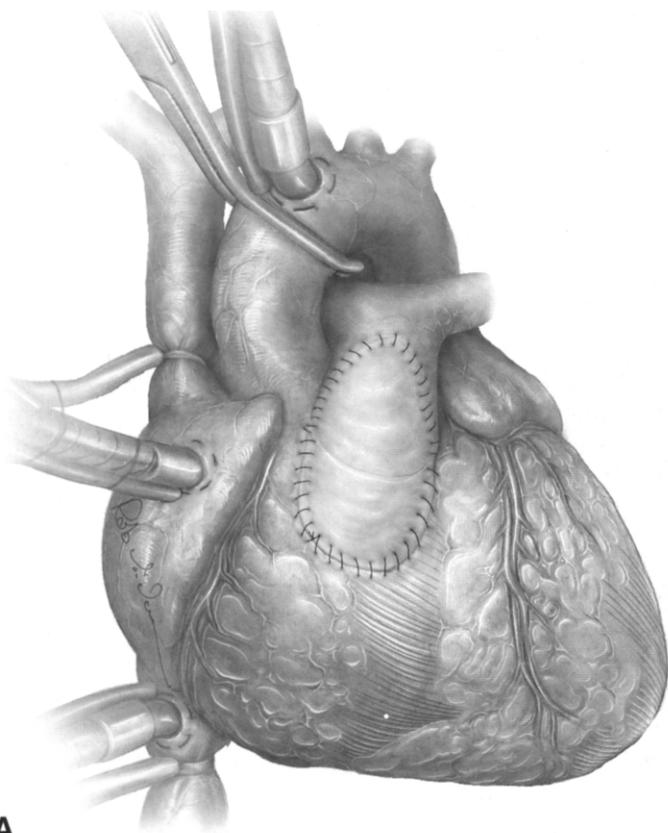


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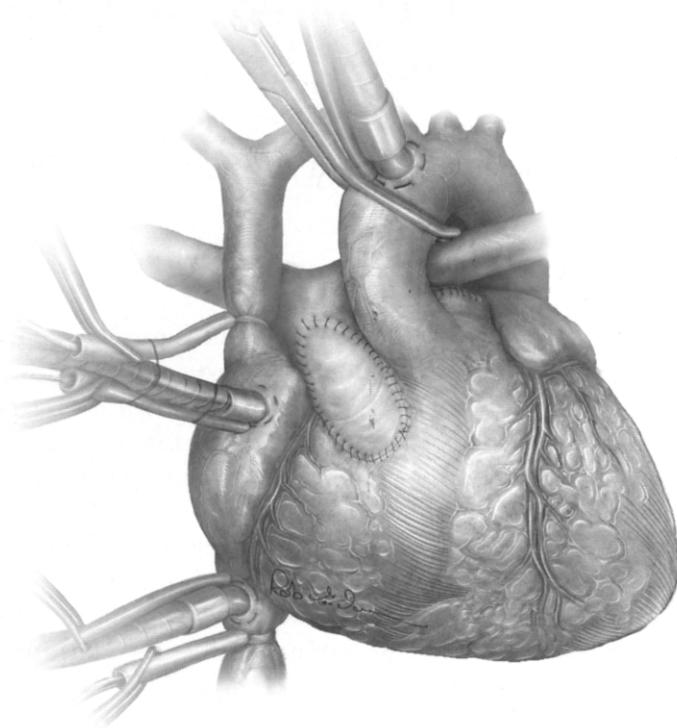
8 The pulmonary arterial trunk is incised longitudinally, and the posterior part is anastomosed to the upper part of the ventricular incision. Generally, it is possible to reimplant one-half the circumference without excessive traction. To limit postoperative pulmonary regurgitation, a monocuspid pericardial valve is constructed. Until recently, we used to include this valve in the anterior patch of the POT repair. We now fix the heterologous pericardium on the ventricular incision.³ This technique is faster than the former one and just as efficient. The dimensions of the valve must be measured according to the diameter that is to be given to the reconstructed POT.



9 The final step is the insertion of an anterior patch extending between the lower part of the ventriculotomy and the main pulmonary artery. The width of the patch is measured according to the patient's body surface using a Hegar dilator, the diameter of which is 1.5 times the size of a normal pulmonary orifice. The length of the patch must be generous to prevent anteroposterior flattening of the POT.



A



B

10 When the great vessels were initially in a side-by-side position, the same type of POT reconstruction is performed either on the left side or, more rarely, on the right side of the aorta.

SUMMARY

Since the introduction of the REV procedure in 1980, this operation has become our procedure of choice for patients with transposition of the great arteries, VSD, and POT obstruction. The classical Rastelli procedure is indicated only in patients in whom the presence of a well-functioning pulmonary valve is deemed necessary (i.e., hypoplastic right ventricle, inadequate pulmonary arterial bed). Compared with the Rastelli operation, the REV procedure may have definite advantages:

1. The REV operation creates a straight, short left ventricular-aortic tunnel, provides proper alignment of the aorta with the left ventricular chamber, and practically eliminates the risk of late subaortic stenosis.
2. Complete repair is feasible in patients in whom a Rastelli procedure would be contraindicated because of unfavorable intracardiac anatomy (i.e., restrictive VSD, abnormal attachment of tricuspid chordae on the conal septum).
3. The absence of an extracardiac conduit to restore the right ventricular-pulmonary artery continuity reduces the need for reoperation due to recurrent POT obstruction. In most patients, the long-term outcome of the reconstructed right ventricular outflow tract may be similar to that of a repaired

tetralogy of Fallot. However, the need to relieve right ventricular outflow tract obstruction, although reduced in comparison with the Rastelli procedure, is not eliminated completely.

4. Because of its feasibility in most intracardiac situations and because it obviates the need for an extracardiac conduit, the REV procedure can be performed in infants and small children, thus avoiding, in most patients, an initial palliative step.

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