THE EXPERIMENTAL PRODUCTION OF INFUNDIBULAR PULMONIC STENOSIS*

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Experimental stenosis of the pulmonary artery was produced in 1916 by Mont Reid, using Halsted's technic of application of a constricting metallic band. Holman and Beck found that this procedure frequently resulted in erosion of the vessel wall, and later Holman applied loose ligatures in puppies which produced stenosis when the animals reached maturity. Hufnagel reported partial resection of the pulmonary arterial wall with closure, thus producing a stenosis. However, in each of these methods the stenosis was produced in the pulmonary artery distal to the pulmonary valve.

This report concerns the experimental production of an infundibular type of pulmonic stenosis. Our interest in this subject began two years ago, and a preliminary report has been previously made. Since then Alden, et al. have described a technic for the production of a similar defect.

DISCUSSION

Infundibular pulmonic stenosis is the most commonly encountered type of pulmonic stenosis in congenital heart disease. An experimental preparation similar to it would be of value in studying the nature of the disorder. Further, there is a group of cardiac malformations which may possibly be benefited by the production of a stenosis of this type. These anomalies have in common the feature of pulmonary hypertension. They include the Eisenmenger complex, the single ventricle without pulmonary stenosis, large ventricular septal defects, and true truncus arteriosus. Surgical relief of these abnormalities is at present not satisfactory, and their correction remains a problem.

As a result of a careful study upon a patient in whom the cardiac findings at autopsy were closely related to those of the Eisenmenger complex, Civin and Edwards suggested that the creation of infundibular pulmonic stenosis might be beneficial. This patient was a 47-year-old male who died of a metastatic carcinoma of the prostate. Although his cardiac history had been minimal and there had been no cyanosis, at autopsy the heart showed a ventricular septal defect, biventricular origin of the aorta, hypertrophy of the right ventricle, a normal pulmonary artery, and a subpulmonary (infundibular) stenosis of the outflow tract of the right ventricle. This stenosis was localized and was thought to allow normal pulmonary outflow, which removed it from the category of the tetralogy of Fallot. The pulmonary arteries and arterioles were histologically normal. These authors interpreted the long survival of their patient to the fact that the stenosis of the outflow tract was of such proportion to create sufficient resistance for the right ventricle to supply blood to the aorta, but leav-
Fig. 1. Simple suture technic in anterior right ventricular myocardium.

Fig. 2. Mattress suture technic with inversion of portion of right ventricular myocardium.

Fig. 3. Technic including both anterior and a portion of the posterior right ventricular myocardium.

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Blalock narrowed the pulmonary artery in two patients with pulmonary hypertension, although these patients did not survive. Muller and Damman have reported the case of an infant of four months with a single ventricle without pulmonic stenosis who was in constant heart failure. A portion of the pulmonary artery was excised, thus narrowing the lumen. The infant was however, for the present, the analysis of the case of Civin and Edwards is challenging.

METHOD

Our interest in the experimental production of infundibular pulmonary stenosis led to the trial of several procedures in an effort to produce a permanent type of obstruction to the pulmonary outflow. In the

**FIG. 4.** Photograph of specimen showing opened right ventricle with pulmonary stenosis produced by technic illustrated in Figure 3.

benefited by the procedure. They have since reported a second successful case.

There is not complete agreement regarding the possible benefit of the production of pulmonic stenosis in certain instances of pulmonary hypertension. In discussing the problem of surgical correction, Goldberg, et al. have disagreed with Civin and Edwards and are of the opinion that the right ventricular strain would persist and that the problem should be attacked by correction of the overriding aorta and ventricular septal defect. This latter is the ideal therapy when technical advances will allow.

first method, through-and-through sutures were placed in the anterior wall of the right ventricle beneath the pulmonary valve. The objective of the procedure was the production of a mass of myocardium to form the obstruction. An illustration of this procedure is shown in Figure 1. The results were not encouraging and the amount of stenosis produced was not adequate. A second method was then tried, with better results. Two or three sutures of the mattress type were placed in the same location. This permitted an inversion of the myocardium. This is illustrated in Figure 2. However,
### Table I. Results in Animals with Infundibular Pulmonary Stenosis Produced by Technic as Illustrated in Figure 3.

<table>
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<tr>
<th>No. of</th>
<th>Date of Operation</th>
<th>Date of Catheterization</th>
<th>Maximal Rt. Ventricular Pressure (mm. Hg)</th>
<th>Recorded Mean Arterial Pressure (mm. Hg)</th>
<th>Maximal Pulmonary Artery Pressure (mm. Hg)</th>
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<tr>
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<td>1/21/52</td>
<td>2/3/52</td>
<td>90/0</td>
<td>*</td>
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</tr>
</tbody>
</table>

* Catheter could not be forced through infundibular stenosis into pulmonary artery despite great effort.
† Measurements taken directly with thoracotomy under endotracheal ether anesthesia.

The results were not those desired, as there was not a marked stenosis produced.

It is the third procedure which was employed that was found to be the most successful. The animal is anesthetized with endotracheal ether. The left chest is entered through the fourth intercostal space, and the pericardium is exposed in the region of the pulmonary conus and upper portion of the right ventricle. The pericardium is incised anterior to the phrenic nerve, and with the finger the heart is delivered anteriorly and rotated toward the left. A suture is placed from the most lateral aspect of the atrio-ventricular groove through the right ventricular wall to the posterior wall and through the area of the crista supraventricularis. The suture is then brought out just to the right of the anterior descending coronary artery.

The amount of tension exerted upon this suture is important, since in some instances it is possible to reduce the pulmonary flow to such a degree that marked bradycardia and cardiac arrest will ensue. Thus, the first knot is laid and the cardiac action is observed for several minutes before the knot is tied. A second suture inferior to the first may be employed to increase the amount of stenosis. A marked thrill is easily palpable in the pulmonary artery. The technic of this procedure is illustrated in Figure 3. A photograph of a specimen produced by this technic shows the opened right ventricle and the infundibular stenosis (Fig. 4).

### Results

A total of 20 adult mongrel dogs were used in this study. Three were subjected to the first procedure described and each of these died in the early postoperative period. Autopsy revealed consolidated pneumonitis in each instance. The stenosis produced in these animals was not satisfactory. The next four animals had stenosis produced by the use of mattress sutures to invert the anterior myocardium. Each of these animals survived, but the maximal right ventricular pressure did not reach the desired level (average of 40 mm. of Hg).

The last 13 animals were subjected to the third procedure described. In the main these animals did well, some dying during the catheterization procedure. Loud systolic murmurs along the left sternal border were present in each instance and were persistent. The right ventricular hypertension has been demonstrated to remain elevated for prolonged periods. The results are presented in Table I.

### Summary

1. Infundibular pulmonic stenosis is the most common type of pulmonic stenosis encountered in congenital heart disease.
2. A method for the experimental production of an infundibular stenosis is presented. Long follow-up indicates that the right ventricular hypertension is persistent.

3. It is postulated that certain congenital cardiac deformities in which there is pulmonary hypertension may be benefited by the creation of an infundibular stenosis.

BIBLIOGRAPHY


Willis, Dry, and Wood: Quoted by Civin and Edwards.