

## A METHOD OF TREATING INFUNDIBULAR PULMONARY STENOSIS

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Valvular and infundibular stenosis of the pulmonary outflow tract can be treated by open resection of the obstructing tissue. In consequence operations of the type devised by Blalock are not as popular as they were.

The desired results can be obtained, by techniques similar to that described by Brock, whether the circulation is temporarily arrested or not. But the most successful cases are those in which the obstruction is muscular and only involves a short segment of the outflow tract. In the latter the stenosis can be relieved by opening the right ventricle, and by removing the bar of muscle adjacent to the ventricular septum. This obstructing diaphragm can also be eliminated by cutting through its anterior wall. Kirklin, operating in 1953, was the first surgeon to succeed in this way (Kirklin, Openshaw, and Tompkins, 1953). He cut through the stenosis by using a wire which disrupted the continuity of the muscle fibres. Kirklin's method has the disadvantage that it leaves a scar after the wound in the heart has been closed, and this becomes undesirable if a long segment of the infundibular muscle is involved. Indeed, in the latter circumstances the method is not feasible.

To meet these difficulties we have developed a technique (Temesvári, 1955a and b), the essentials of which are that we cut out a piece of the obstructing ventricular wall, 3 to 4 mm. in width, and cover the defect thus created with a full-thickness skin graft. The stenosis is alleviated not only because some of the obstructing tissue is removed but also because the grafted area expands during systole.

Before trying this operation in man, we carried out many animal experiments to determine how much of the right ventricular wall could be removed without impairing its function as a pump, and we found that excisions of the dimensions described had no injurious effect. We also compared the healing qualities of free and attached grafts and came to the conclusion that free grafts

healed well. In some of these experiments the pulmonary artery was partially occluded to raise the pressure in the right ventricle, and under these circumstances the grafts healed well and aneurysms did not form. None of the grafts ruptured.

### CASE HISTORY

A boy aged 7 was admitted on June 5, 1956, suffering from Fallot's tetralogy. He had been cyanosed in some degree ever since birth, and had had frequent episodes of circulatory failure. During these attacks he used to squat, would become very cyanosed, and would often faint.

There was marked clubbing of the fingers and toes, and there was a coarse systolic murmur audible over the entire front of the heart. The murmur was

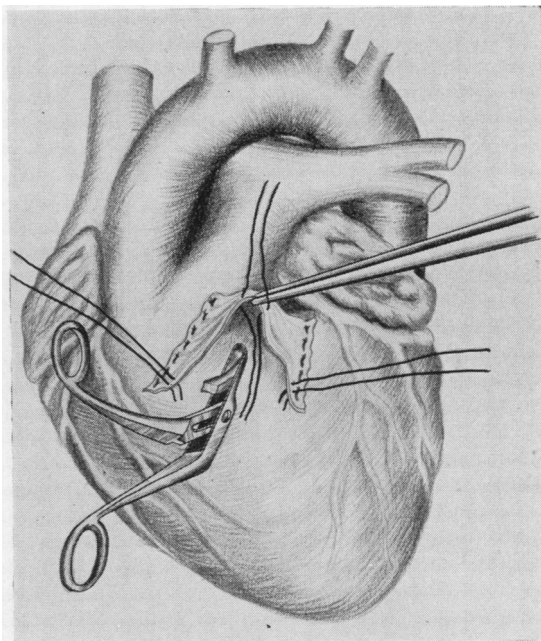


FIG. 1.—Operation to correct infundibular stenosis.

loudest in the pulmonary area and the pulmonary second sound was absent.

In 1954 the erythrocyte count was 6,400,000 and by 1957 it had risen to 7,000,000. The haemoglobin was 22% and the haematocrit 69.

The radiographs showed a typical "cœur en sabot," the pulmonary arteries were inconspicuous, and the apex was displaced to the left and upwards. The right ventricle was considerably enlarged and the left ventricle was small. The lung fields were oligæmic. There was no hilar dance on screening. The angiocardigrams were compatible with a diagnosis of Fallot's tetralogy, and very little of the contrast medium found its way into the pulmonary arteries. There was no post-stenotic dilatation.

Cardiac catheterization was not considered necessary and a diagnosis of infundibular stenosis was made.

Littmann operated on June 15, 1956, under intratracheal anaesthesia (Fig. 1). The chest was entered through the left sixth intercostal space. The pericardium was incised, exposing the enlarged right ventricle and a narrow pulmonary artery. No post-stenotic dilatation could be seen. An intense thrill was palpable over a 3-cm. length of the infundibular part of the right ventricle, fading out slightly toward the pulmonary trunk and branches. The length of the infundibular stenosis having been palpated, an autogenous free skin graft, 4 cm. in length and 3 cm. wide, was sutured over the area by interrupted sutures. One margin of the graft was left free and a few sutures were placed to be tied later. The free edge of the graft was then raised by forceps, and near to its lower margin an incision into the ventricle was made with a Graefe's scalpel. Through this wound we cut out a piece of the heart wall, 2 to

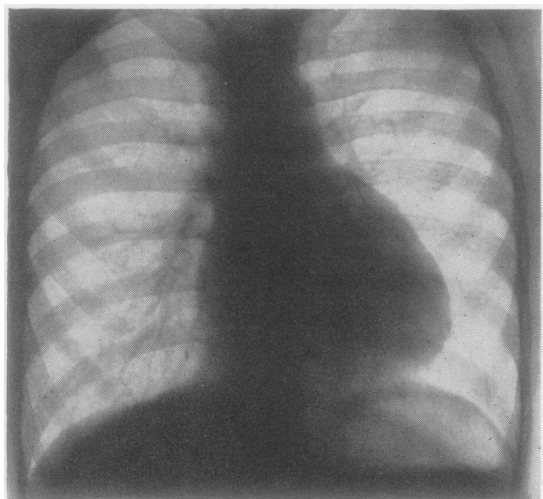


FIG. 2a.—Before operation. The left ventricle is small.

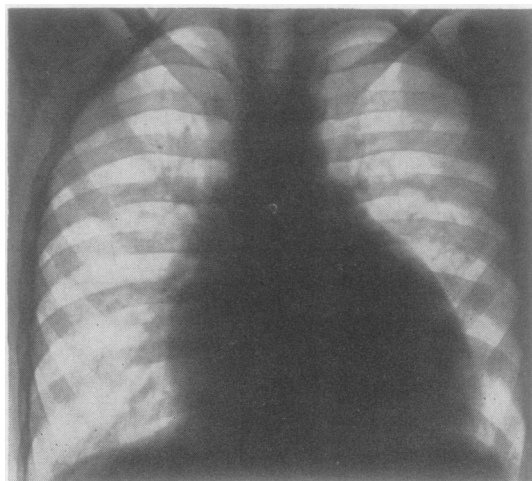


FIG. 2b.—After operation (June 20, 1956). Left ventricle enlarging.

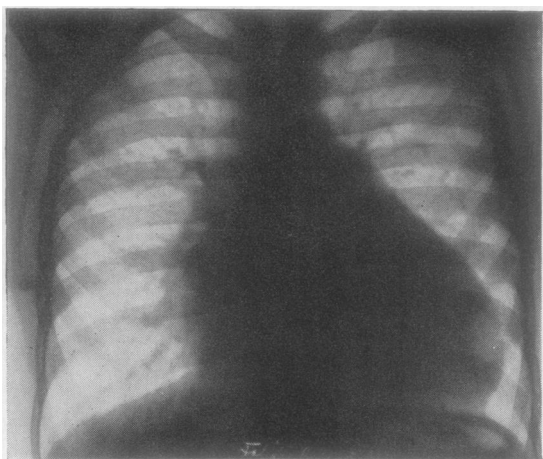


FIG. 2c.—After operation (July 17, 1956). Left ventricle at its largest.

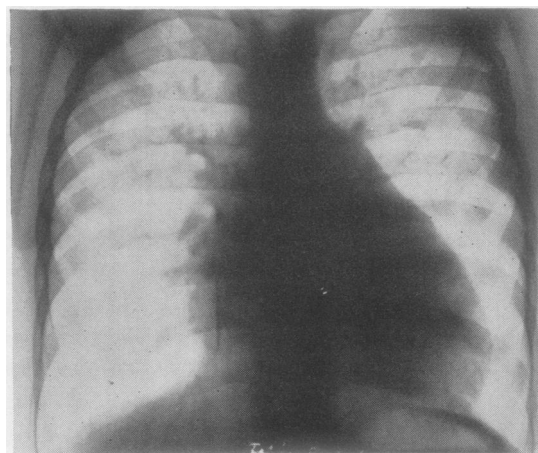


FIG. 2d.—After operation (May 20, 1957). Left ventricle diminishing in size.

	Before Operation		After Operation	
<b>Laboratory findings:</b>				
Erythrocyte count	6,400,000	1953	4,400,000	2 weeks
	7,000,000	1956	3,800,000	1 year
Haemoglobin ..	22 g. %	1956	13.2 g. %	2 weeks
			12.3 "	1 year
Haematocrit ..	69	20.9.53	39	2 weeks
			38	1 year
Bing's test, resting	38.6 ml.	20.9.53	33.4 ml.	17.9.56
Oxygen consumption index:				
Resting ..	43.0 "	5.6.56	32.8 "	27.5.57
After exercise ..	26.9 "	20.9.53	30.8 "	17.9.56
	33.0 "	5.6.56	51.0 "	24.5.57
Percentage increase of O <sub>2</sub> consumption after exercise	43%	20.9.53	65%	17.9.56
	61%	5.6.56	106%	24.5.57
<b>Radiological findings</b>				
Hilar pattern ..	Hardly visible		Normal	
Lung fields ..	Very light		"	
Pulmonary arch in antero posterior radiographs ..	Absent		Present	
Cardiac apex ..	Dislocated leftward and upward		Dislocated leftward and downward	
In the oblique II	Right ventricle very big		Much smaller 20.6.57	
	Left ventricle small (Fig. 2 (a))		Somewhat bigger (20.6.56). Bigger (17.7.56). Bigger still (17.1.57). Smaller (20.5.57) (Fig. 2 (b) (c) (d))	
<b>Electrocardiogram studies</b>				
	Standard leads: Sinus rhythm. P. cong. In all 3 leads main excursion is downwards; disturbance of intra-ventricular conduction		Standard leads: Excursions small	
	Chest lead: Horizontal heart position, hypertrophy of right ventricle, incomplete right bundle branch block (5.6.56)		Chest lead: T inverted in V <sub>2</sub> , V <sub>3</sub> , and V <sub>4</sub> (24.6.56, 9 days after operation)	
			Standard leads: Excursions smaller	
			Chest lead: Elevated ST segment and pointed inverted T in V <sub>2</sub> , V <sub>3</sub> , V <sub>4</sub> resemble curve of coronary type (30.6.56, 14 days after operation)	
			Standard leads: Main excursions now positive	
			Chest lead: ST-T changes unaltered. The R wave has increased in height in V <sub>2</sub> and V <sub>4</sub> (as result of increased left ventricular work) (7.9.56, about 3 months after operation)	
			Standard leads: Excursions have regained their normal height	
			Chest lead: ST-T changes unaltered in V <sub>2</sub> , V <sub>3</sub> , and V <sub>4</sub> . In V <sub>2</sub> and V <sub>4</sub> height of R has further increased; left ventricular work has increased (20.5.57, about 1 year after operation)	

2.5 cm. in length and about 5 mm. in width, corresponding to the infundibular stenosis. The relief of stenosis in its entire length was confirmed by palpation with the little finger. The remaining sutures were then knotted and the bleeding of small vessels was arrested by stitches. Circulation had been satisfactory throughout the operation. The skin graft on the right ventricle showed the expected paradoxical movements, that is, it dilated during systole.

The patient tolerated operation well, woke up a few minutes after its completion, and was slightly cyanotic. Eight days after operation he was allowed to get up. At that time his cheeks were pink and there was no fever. Three weeks after operation he was sent home and has been examined several times since then. During the months that have elapsed since operation no cyanosis or attacks associated with squatting have occurred. The intensity of the systolic murmur has decreased over the heart and the second pulmonary sound is clearly audible. The patient has grown, moves about freely, and rides a bicycle.

The laboratory, radiological, and electrocardiographic examinations show that a substantial improvement has taken place. Comparative lists of the pre- and post-operative findings are given in the Table.

A comparison of the pre-operative and post-operative results reveals that the erythrocyte count has become normal, the haemoglobin level has decreased from 22 g. % to 12.3 g. % in one year, and the haematocrit has decreased from 69 to 38. Oxygen consumption on exercise has increased. After operation the hilar pattern on radiography became normal. In the antero-posterior radiographs the pulmonary arch became convex, but no aneurysmal bulging could be seen. The left ventricle has increased in size, and this may be explained by the fact that the left ventricle now pumps larger blood volumes; it has dilated and hypertrophied. The circulatory equilibrium has been gradually restored. The most recent radiograph shows that the left ventricle has decreased in size. The E.C.G. studies\* show that before operation there was an extreme right heart preponderance, whereas after operation the right deviation was slight. The so-called coronary type curves did not appear in the chest leads immediately after operation because of the excision made from the right ventricle. It is possible that the E.C.G. signs of the transient sterile pericarditis obscured the above changes. The subsequent increase in the height of the R wave suggests, in agreement with the radiological evidence, that the work of the left ventricle has increased.

The results indicate a gradual improvement in the patient's condition since operation. As pulmonary blood flow increased, the left ventricle had to adapt itself to the handling of the increased volumes; it became bigger at first and then gradually decreased in size. After the obstruction had been eliminated,

\* The electrocardiograms submitted for publication were not suitable for reproduction; but the points described in the text are confirmed.—EDITOR.

cyanosis disappeared completely; there is no dyspnoea even when mounting steps, and the patient is growing normally.

#### SUMMARY

Kirklin's statement (Kirklin *et al.*, 1953) that in infundibular stenosis excision of the stenosed ring will abolish the obstacle to pulmonary blood flow has induced us to develop our method of treating this condition. We do not think that it suffices to resect the anterior part of the infundibulum, but use a free skin graft to cover the defect. After animal experiments we have carried out the first

operation in man, with success. After more than one year the skin graft has grown perfectly into the myocardium; no aneurysm has developed. After the obstruction to the pulmonary circulation was overcome, the patient's condition improved. This improvement has been confirmed by laboratory, radiological, and electrocardiographic studies.

#### REFERENCES

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