

the side opposite the descending aorta. In other words, if the aorta were on the left side, he would use the right subclavian artery for the shunt. Under certain conditions, the innominate artery was used for making the shunt. (Figure 2.)

In 1945 Dr. Potts² performed a shunt operation connecting the aorta and the left pulmonary artery for treatment of Fallot's tetralogy. This operation has been used for children under three years of age.

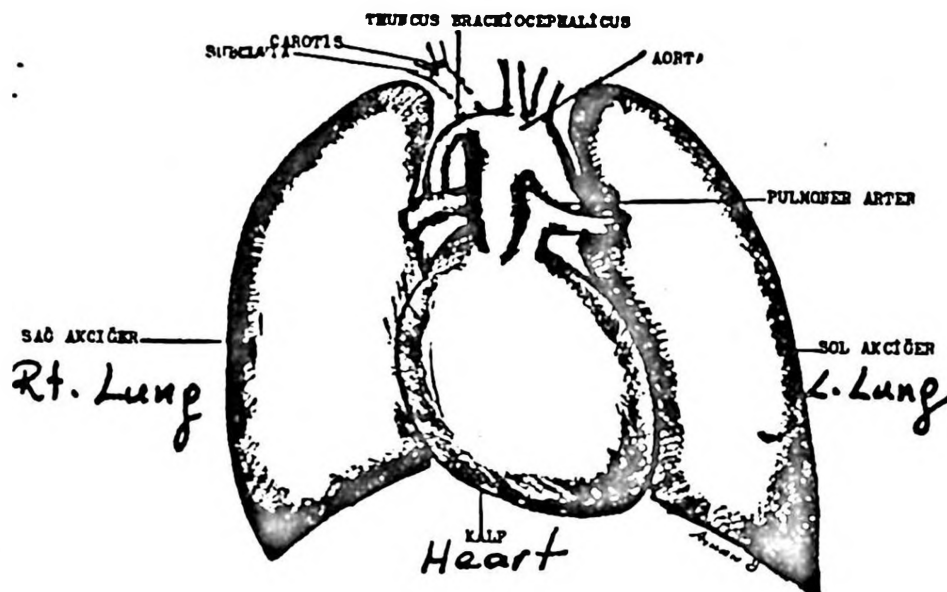


Figure 2. Shows standard Blalock shunt operation on the right side.

In 1948 Dr. Brock³ described an operation which eliminated pulmonary valvular stenosis and reported successfully treated cases of tetralogy. However this type of operation has not been widely used in the treatment of tetralogy of Fallot.

The most generally accepted method of treatment for tetralogy of Fallot is Blalock's shunt operation. Performance of the operation on the left side, however, often produces a kink in the subclavian artery at its junction with the aorta. Dr. Shumaker and Blalock⁴ suggested an elevation of the entire left pulmonary hilus in order to decrease the degree of kinking. This procedure was not entirely satisfactory, and Dr. Shumaker⁵ then tried to re-anastomose the subclavian artery as a separate graft between the aorta and the pulmonary artery.

Dr. Gross⁶ extended the short subclavian artery with a homograft or teflon graft to anastomose it to the pulmonary artery.

Oeconomos⁷ described a shunt operation between the right ventricle and the left pulmonary artery in which a synthetic graft was used to increase the pulmonary flow.

Glenn⁸ used the superior vena cava in an end to end anastomosis with the right pulmonary artery in order to change the direction of venous blood flow directly to the lung. This operation is very useful in the treatment of cyanotic heart conditions, including tetralogy of Fallot.

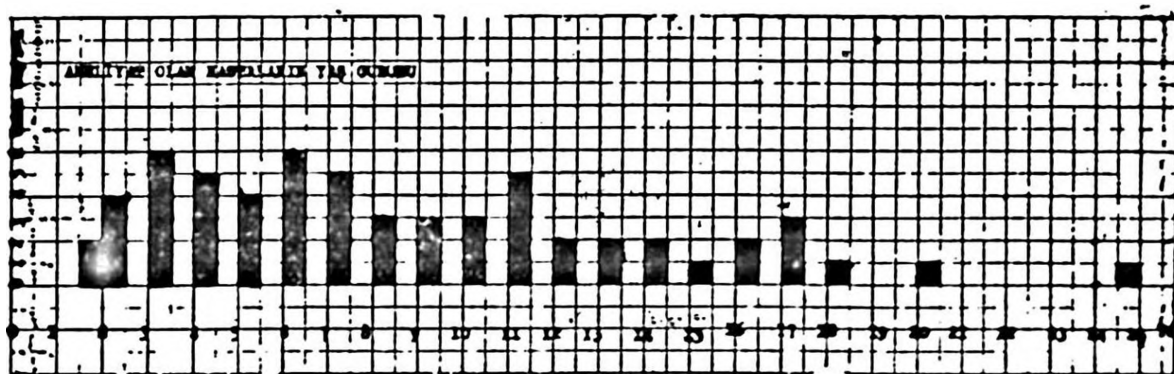
Since 1955 Dr. Lillihei,⁹ using the heart-lung machine, has corrected anomalies of Fallot's tetralogy. His technique has been widely used in such cases.

In spite of all these new and modified methods of shunt operations, the standard Blalock shunt operation is still the most commonly used technique in the treatment of tetralogy of Fallot. At Hacettepe Medical School we have developed a modification of the standard Blalock operation which has eliminated kinking of the left subclavian artery.

Material and Methods

Of the 38 patients on whom modified shunt operations were performed at Hacettepe Hospital up to 1963, the majority were under 16 years of age (See Table 1).

TABLE 1
AGE RANGE OF MODIFIED SHUNT OPERATION PATIENTS TO 1963



Briefly, our modification consists of placing an Ivalon* sponge under the left subclavian artery after the anastomosis with the left pulmonary artery. By this means we elevate the left pulmonary artery and create a smooth curve of the subclavian artery (Figure 3).

* Ivalon is a synthetic material manufactured by Clay-Adams, Inc., New York, New York.

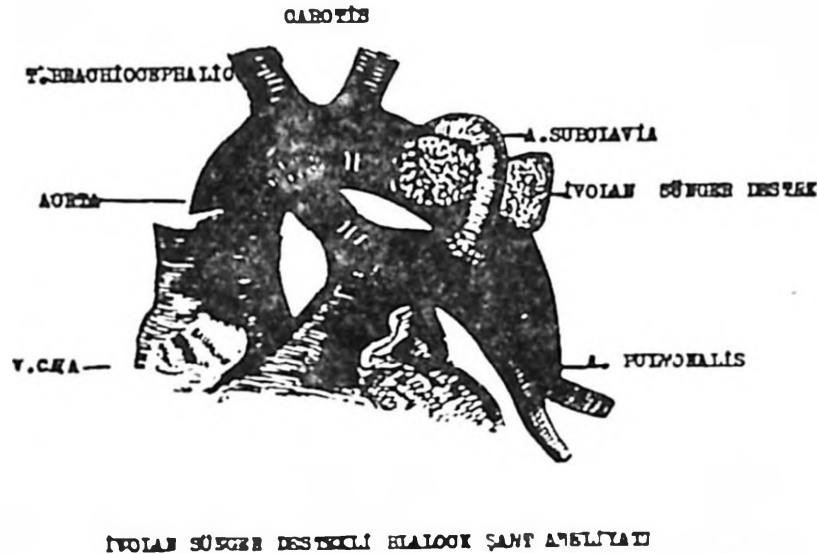


Figure 3. Modified Blalock Shunt operation. One can see the Ivalon sponge placed under the subclavian artery.

Our technique was tested extensively on animals prior to its use on humans. A normal Blalock shunt was performed on 15 dogs. Pulmonary artery pressures were recorded by a Sanborn pressure recording machine before the shunt, after the shunt, and again after the Ivalon sponge had been placed under the left subclavian artery. Thus we could determine if any pathological change had occurred in pulmonary artery pressure. After performing the shunt, the pulse pressure in the pulmonary artery decreased. When the Ivalon sponge was placed under the subclavian artery, there was a further decrease in the pulmonary pulse pressure. The shunt caused a very slight increase in systolic pressure of the pulmonary artery and a marked increase in diastolic pressure. After placing the Ivalon sponge under the subclavian artery the diastolic pressure was further elevated, whereas the systolic pressure in the pulmonary artery remained steady. This indicated that there was a continuous blood flow from systemic circulation to pulmonary circulation. Figure 4 shows pulse pressure changes in the pulmonary artery.

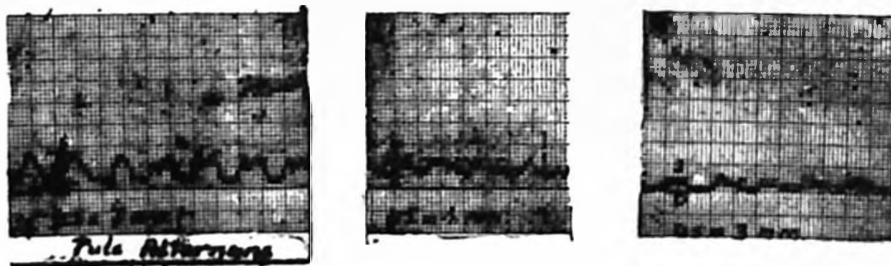


Figure 4. Shows pulmonary artery pressure changes after Blalock shunt and with Ivalon support under the subclavian artery in dogs.

- pulmonary artery pressure before shunt.
- after shunt operation.
- after placement of Ivalon sponge.

We made the same pressure measurements when performing this operation on humans, and the results were similar to those obtained experimentally with dogs, except that the diastolic pressure increase was more marked (Figure 5). The smooth curve of the subclavian artery can be easily seen after the sponge has been put in place, and continuous thrill in the pulmonary artery is greatly increased.

We have always performed the Blalock shunt operation from the left side in tetralogy cases, using the left subclavian artery before its branches for the shunt. End to side anastomosis of the subclavian artery with the pulmonary artery is done with continuous sutures on the back, and interrupted sutures on the front, using 5-0 C.V. Ethicon silk. Then the spool-shaped Ivalon sponge (pressed 2 to 1), one inch long

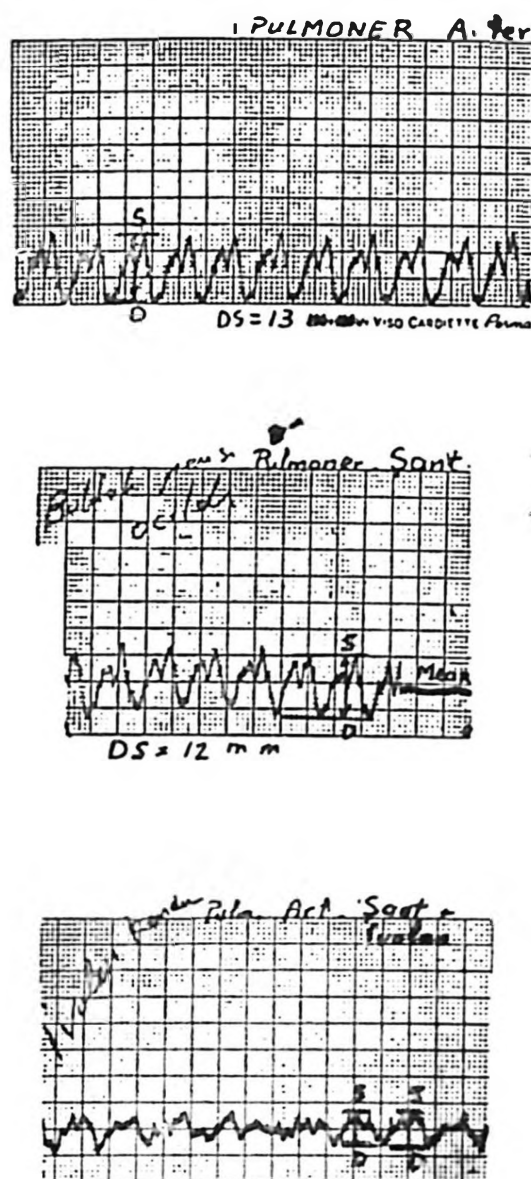


Figure 5. Shows pulmonary artery changes after the shunt and after a shunt with Ivalon sponge support on humans.

- pulmonary artery pressure before shunt.
- after shunt.
- after placing Ivalon sponge under the subclavian artery.

and one-half inch to three-quarters of an inch in diameter, is placed under the subclavian artery without using any suture material. The sponge will remain in place "squeezed" between the subclavian artery and the aorta. In four cases we did suture the sponge to the aortic *adventicia* in order to pull the subclavian artery into place, but generally no sutures are necessary.

Discussion

In the standard Blalock shunt operation, the surgeon performs the operation from the side opposite the descending aorta. About 80 per cent of the thoracotomies are thus performed from the right side, and about 20 per cent from the left. We have, however, consistently performed all thoracotomies from the left and used the left subclavian artery in anastomosis. Under these circumstances, if the aorta is on the right, we perform a conventional Blalock shunt operation. If the aorta is on the left side, we perform a modified Blalock shunt operation with the Ivalon sponge, as described above. The advantage of left side thoracotomy is that it decreases the time required for the operation; we averaged one hour and twenty-five minutes skin to skin. It is also much easier to dissect the pulmonary artery and the subclavian artery from the left than from the right. Working from the left, the surgeon is less likely to make mistakes, such as using the pulmonary vein for anastomosis as has been reported in right side shunt operations. Operative mortality is low, and an additional advantage to performing the operation from the left is that the surgeon can perform a Potts' operation or a Shumaker graft should it be more suitable under the particular circumstances encountered.

Results

We performed this operation on 38 patients between the ages of 1.5 and 16 years (average, seven years) with good results. The patients were followed closely for a period of from one to four years. Phonocardiograms showed continuous murmur in 35 patients in follow-up examinations. Cynosis almost disappeared in 68.2 per cent of the patients, decreased in 27.0 per cent, and there was no change in 4.8 per cent. General physical activities were very much improved in 41.9 per cent of the patients, moderately improved in 55.0 per cent and there was no change in 2.6 per cent. There was a decrease in hemoglobin ranging from three to 12 grams, with an average of 6.5 grams. Hematocrit levels dropped to between five and 28 per cent, with an average of 10.7 per cent. Electrocardiograms showed less

heart hypertrophy compared with preoperative studies. We have not performed open-heart surgery on any of these patients.

We had two patients with postoperative intrathoracic bleeding which required emergency thoracotomy. We evacuated the blood in the chest without locating any definite bleeding points, but there was no further bleeding in these two cases.

Two of our patients died, one of bilateral bronchopneumonia, twenty days after discharge from the hospital. The other patient died of gastrointestinal hemorrhage five months after discharge from the hospital. Although we were unable to perform autopsies in these cases, we feel that the deaths were essentially unrelated to the operation.

Summary

We performed left sided Blalock shunt operations on 39 pediatric patients with Tetralogy of Fallot. We used Ivalon sponge support under the subclavian artery to prevent the kinking of this artery at the origin of the aorta.

REFERENCES

1. Blalock, A., and Tausig, H. B.: The surgical treatment of malformations of the heart, in which there is pulmonary stenosis or pulmonary atresia, J.A.M.A. 128: 189, 1945.
2. Potts, W.J., Smith, S., and Gibson, S.: Anastomosis of the aorta to a pulmonary artery, J.A.M.A. 132: 627, 1946.
3. Brock, R. C.: Pulmonary valvulotomy for the relief of congenital pulmonary stenosis. (Report of three cases). British Medical Journal 1: 1121, 1948.
4. Blalock A.: The technique of creation of an artificial ductus arteriosus in the treatment of pulmonic stenosis, The Journal of Thoracic Surg. 13: 244, 1947.
5. Shumacker, H. B., Jr.: Suggestions concerning use of subclavian which arises from aorta in treatment of tetralogy of Fallot, Yale J. Biol. and Med. 23: 486, 1951.
6. Gross, R. E., Alexander, H. H. Jr., and Peirce, C. E. 2nd: Homograft extension of subclavian artery, Surgery, Gynecology and Obstetrics 88: 639, 1949.
7. Oeconomos, N.: (Polyclin d'Athens): Traitement de la stenose pulmonaire sous vision directe. Description d'une technique nouvelle et presentation d'un premier cas opere avec succes (Surgical treatment of pulmonary stenosis under direct vision: successful outcome in first case operated on by a new technique). Presse Med. 64/33: 776, 1956.
8. Glenn, W. W.: Circulatory bypass of the right side of the heart, IV shunt between superior vena cava and distal right pulmonary artery, report of clinical application. New England Journal of Medicine 259: 117, 1958.
9. Lillehei, C. W., Cohen, M., Warden, H. E., Read, R. C., Aust, G. B., DeWall, R. A., and Varco, R. L.: Direct vision intracardiac surgical correction of the tetralogy of Fallot, pentalogy of Fallot and pulmonary atresia defect, Ann. Surg. 142: 418, 1955.