Tetralogy of Fallot: Surgical Treatment

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Since Blalock published his first report on the surgical treatment of pulmonary stenosis, we became greatly interested in this subject.

While performing an necropsy on a ten year old child who had tetralogy we found an abnormal vessel which connected the left subclavian and left pulmonary arteries (Fig. 1); this vessel had a very small lumen and evidently was unable to supply enough oxygenated blood to counteract the cyanosis. Nevertheless, this observation was a vivid proof that Nature, in order to overcome the disabling effects of cyanosis, used the same procedure that Taussig advocated.

Last year we started to operate on cases of tetralogy having dealt, up to now, with 17 cases which are summarized in Table 1. We are aware, of course, that with this meager experience no conclusions whatsoever can be drawn, but we wish to stress some practical points which evolved from our work.

At the outset we had to decide between the two operations which following Taussig's conception were developed to improve the physiologic status of these cyanotic patients: Blalock's and Potts'.

Blalock's technic seemed more advantageous considering the fact that if we had an accident the operation could be interrupted at any stage without any major complication; furthermore, should the follow-up of these patients show the inadequacy of the surgical ductus arteriosus to solve the abnormal physiologic situation or should well known complications of the congenital patent ductus, such as subacute bacterial endocarditis, arise we could proceed to treat these cases as we do with any patent ductus. That much cannot be said of Potts' operation.

To establish a sound comparison, both technics should have been performed in the same number of cases; we have not done so on account of the scarcity of Potts' clamps which were not available until very recently.

Although the tetralogy of Fallot is described as a fairly standard syndrome, there are all varieties and variations of the conditions of this condition, all of which are not amenable to surgical treatment. It is obvious therefore that an accurate diagnosis is an essential prerequisite to consider the surgical possibilities of a case of tetralogy.
An accurate diagnosis may only be accomplished by two methods: angiocardiography as described by A. Castellanos and catheterization of the heart as described by Cournand.

We have used angiocardiography routinely and have wondered why it is not widely used in the United States. Its technic is simple and may be easily mastered. It renders valuable information such as the position, size and shape of the heart chambers and great vessels (Fig. 2).

This method avoids many surgical fatalities in cases where practically all the pulmonary flow enters the lung through collaterals of the bronchial artery, which have to be divided in exposing the pulmonary artery for anastomosis. If we divide all these collaterals and there is complete absence of the pulmonary artery,

<table>
<thead>
<tr>
<th>Case</th>
<th>Age in Years</th>
<th>Operation</th>
<th>Position of Aortic Arch</th>
<th>Operative Approach</th>
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<th>Alive</th>
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<td>Left</td>
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<tr>
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<td>Left</td>
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</table>

(1) Ligation and section of persistent left cava superior.
(2) No pulmonary artery found.
(3) When the pleura was opened, the patient developed auricular fibrillation; blood pressure fell to zero. Cardiac massage was performed. Intravenous digitalis was given. Recovery ensued after half an hour. The operation was postponed.
(4) Same case as referred in No. 13; developed same complication while receiving anesthesia.
acute anoxemia develops and death ensues. Blalock refers 18 fatalities following operations in which it had been impossible to find a pulmonary artery and Humphreys one. If these patients had had a preoperative angiocardiography it would have shown the absence of the pulmonary artery and the operation would not have been performed.

The location of the aorta may be exactly determined by angiocardiography and in some cases we have been able to measure the length of the subclavian artery.

This procedure may be performed at any age, has no complications and the only warning we have to report from the surgical point of view, is to defer the operation at least a week after its performance, because it increases bronchial secretion.

Catheterization of the heart is a cumbersome affair that cannot be used as a routine examination. It necessitates a special team to produce satisfactory results although we must recognize that in the hands of such a team it yields invaluable information. It entails some risk and fatalities have been reported. It requires the joint work of a cardiologist, anesthetist, cardio-vascular surgeon, physiologist, chemist and radiologist and, at least at present, should be reserved for research centers.

We have not used any particular preoperative preparation. The anesthesia has been intratracheal with cyclopropane and oxygen. If we have extrasystoles we change to ether. To facilitate the intratracheal intubation we have not hesitated to use 1 or 2 cc. of curare intravenously, without any untoward effects.
An approach through the third intercostal space, similar to that of anterior thoracotomy is used. Lately we have tried the posterolateral approach through the fourth intercostal space and find it highly satisfactory, because the dissection of both arteries, pulmonary and subclavian, is easier and the anastomosis may be performed smoothly as we have a clean access to the anterior and posterior aspects of the suture.

Blalock recommends that the incision should be made on the side opposite that on which the aorta descends. We have broken this rule in cases where the angiocardiography showed a short right subclavian. We recognize that the subclavian artery branch of the innominate provides a better angle for the anastomosis than the subclavian branch of the aortic arch, but the latter can function satisfactorily supplying enough blood to improve the cyanosis.

The exposition of the left pulmonary artery is simpler than the right. It is the highest structure of the pedicle; it runs a straight course towards the lung and can be distinctly isolated from the veins; it is the only vessel that surrounds the superior lobe on its way to the interlobar fissure. Such is not the case with the right pulmonary artery which springs up from the pedicle following an upward course and divides in two branches almost at the outset.

The vena cava should be continuously retracted in this dissection and sometimes the pulmonary veins too are in front of the artery and extreme caution must be exerted not to confuse them, as has been the case in Blalock's experience.

All these considerations led us to the thought of advocating the left side approach systematically. If we find a good subclavian which may be anastomosed to the pulmonary artery with a good angulation we perform the Blalock operation, if we do not we turn to Potts' technic. This procedure, which we followed in the last case operated on, enables us to avoid having to perform the anastomosis using the carotid artery, with its high percentage of cerebral complications.

The vagus nerve is routinely injected with 2 cc. of 1 per cent novocain to avoid reflexes. In order to procure an adequate length of the subclavian artery we repeatedly have ligated the inferior thyroid, vertebral and even the internal mammary arteries, with no embolic or thrombotic complication.

The incision on the pulmonary artery is done transversely whenever it is possible; if not, we resort to the longitudinal incision.

We have not used more than 250 cc. of plasma during the opera-
tion; no other infusion has been administered, from our second case on.

The postoperative course has been uneventful. The two deaths reported in Table 1 correspond, one to a vago-vagal reflex during the dissection of the subclavian artery; it appears that the nerve had not been properly injected; the second fatality occurred four hours after the operation. The necropsy revealed nothing but a marked pulmonary engorgement. We feel that this baby died due to an overdose of saline solution.

Case 3 had a persistent patent left vena cava superior, which opened in the left auricle, with a coexisting tetralogy of Fallot; this anomaly was distinctly shown by the preoperative angiocardiography (Fig. 3). This boy had our highest hematocrit reading: 91 per cent. The performance of Blalock's operation was considered but finally we decided that the division and ligation of the left vena cava superior would reduce the amount of blood with a low level of oxygen saturation returning to the heart, with a subsequent amelioration of cyanosis.

Following the operation (Fig. 4) the hematocrit reading dropped to 56, the cyanosis diminished and the well being of the patient was notably improved.

We have seen this patient two months after the operation and the contrast with his preoperative status is remarkable, especially relating to his working capacity. This boy, who hardly could walk without a fainting spell, is now able to play baseball.
SUMMARY

Seventeen patients with tetralogy have been operated on with a mortality rate of 11.6 per cent.

The value of angiocardiography is emphasized, and its use is recognized as a routine exploration. It avoids fatalities in cases where no pulmonary artery is found.

The operation of a case of persistent left vena cava superior, opening in the left auricle, is reported.

The left thoracic approach and postero-lateral incision are recommended as they give the alternative of performing either Blalock's or Potts' operation.

SUMARIO

Se presentan diecisiete casos de Tetralogía de Fallot, operados con una mortalidad de 11.6 por ciento.

Se hace especial hincapié en el valor de la angiocardiografía, la cual se preconiza como una exploración de rutina. Su empleo evita la muerte de aquellos casos en que disecado el pedículo pulmonar, no se encuentra arteria pulmonar.

Se reportó la operación de un caso con vena cava superior izquierda, la cual desembocaba en aurícula izquierda.

Se recomienda el acceso por hemitórax izquierdo, así como la incisión posterolateral, ya que de este modo si no se puede practicar la operación de Blalock, se hace la de Potts.

Addendum: Since this paper was written, 11 additional patients have been operated on with one fatality, which yields a mortality percentage, considering the whole group, of 10.7 per cent.

REFERENCES