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SOME CONSIDERATIONS ON THE BLALOCK OPERATION

by

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Since Blalock (1945)[1], patients with pulmonic stenosis or atresia in whom some mixed venous blood enters the aorta have been benefited by the creation of an artificial ductus arteriosus. The surgical procedure consists in the following anastomosis between the systemic and pulmonary arteries: (1) the proximal end of the right or left subclavian artery and the side of the right or left pulmonary artery: (2) the proximal end of the right or left subclavian artery and the distal end of the right or left pulmonary artery.

However, an end-to-end anastomosis is not to be prefered to an end-to-side suture, despite the fact that the former is easier. There are a number of reasons why this is so[2], among which the most important one is that if, following an end-to-end anastomosis in a patient who has atresia or marked stenosis, a collapse of the lung develops on the side of the operation, the limited flow of blood through the opposite lung may not be sufficient to maintain life.

Despite the disadvantages, this method must be carried out, when the subclavian artery is too short or the pulmonary artery is too slender to performe a satisfactory end-to-side union.

Is it constantly an effective surgical procedure, if it is not followed by atresia or marked stenosis? The present paper deals with this problem.

CASE REPORT

H. Y., an 18 years old female who had been cyanosed since birth, had no complaint until 5 years of age. Since then her activity was limited due to palpitation and dyspnea aggravated with the slightest exercise. About 10 years of age, clubbing of the fingers and toes appeared. Later on temporary improvement occured spontaneously. Recently she experienced episodes of severe sudden dyspnea with palpitation which subsided a few days later through a rest cure. After that she had hemoptysis amounting to a staining of the sputum.

On admission, August 2, 1955 she was somewhat underdeveloped and considerably cyanotic, weighing 40.5 kg. It was proved that she had a precordial bulging. There was a loud systolic murmur over the fourth interspace to the left of the sternum. Blood pressure was systolic 120 mm Hg and diastolic 72 mm Hg. The

hemoglobin was 16 g per cent, with an erythrocyte count of 4.92 million. The electrocardiogram showed the presence of right axis deviation in the standard leads, a peaked P wave in Lead I and II, and a wide R wave in Lead V_1 and V_2. Roentgenogram in the posteroanterior view revealed a " boot-shaped " heart due to a concavity in the conus region and elevation of the apex. The normal pulmonary vascularity was absent. The circulation time from arm to lung (ether method) was 10.2 seconds and from arm to tongue (decholin method) 9.8 seconds. Hepatic disturbance could not be proved by means of the bromsulfalein test. Cardiac catheterization revealed the following: in the right auricle blood pressure was 7.2 mm Hg (mean) and oxygen-content of the blood was 15.94 Vol %; in the right ventricle 114/12.6 mm Hg and 16.6 Vol %; in the brachial artery 115/67 mm Hg and 21.93 Vol %; the blood volume shunting through the interventricular defect amounted to 0.4 *l*/min. It was impossible to introduce a catheter into the main pulmonary artery from the conus.

The diagnosis of tetralogy of Fallot was made on the physical and laboratory findings.

An operation was undertaken on August 20, 1955. Induction of anesthesia was Pentobarbital Sodium-Succinyl Cholin Chloride. A cuffed endotracheal tube was inserted, and then anesthesia was maintained with ether and oxygen. With the patient in the supine position, the left pleural cavity was entered through a submammary incision transversing the third interspace. The lung appeared normal, there were no adhesions and no increase in vascular collateral channels in the mediastinum. Over the region of pulmonic valve thrill was felt. The left subclavian artery, which was 6 mm in diameter, was implanted into the left pulmonary artery 8 mm in diameter in an end-to-side manner. However, it was less satisfactory because of a considerable tension made on the anastomosis portion. Then an end-to-end suture was attempted. In performing it, the suture employed is a continuous adventitia-to-adventitia approximation in the posterior half and a continuous intima-to-intima approximation in the anterior half of the circular anastomosis. Immediately after completion of the anastomosis, arterial oxygenation increased to 89 per cent from 74 per cent. Four hours after operation the patient came out from narcosis. Cyanosis disappeared on the next day. About forty-two hours after operation she complained of sudden severe dyspnea with cyanosis and then became unconscious. At that time auscultation revealed no respiratory sounds over the left chest, and reddish serous fluid was proved profusely from a Nélaton's catheter introduced into the left pleural cavity. Two hours later she succumbed.

At autopsy the diagnosis of Fallot's tetralogy was justified. Examination of specimens revealed that the left lung was more voluminous and the heart was, on the whole, smaller than normal. Mitral annulus was 58 mm in circumference: mitral valve orifice was so small that it hardly permitted passage of an index finger. However, the leaflets themselves were competent. The thickness of the right ventricle wall was 17 mm and that of the left 15 mm.

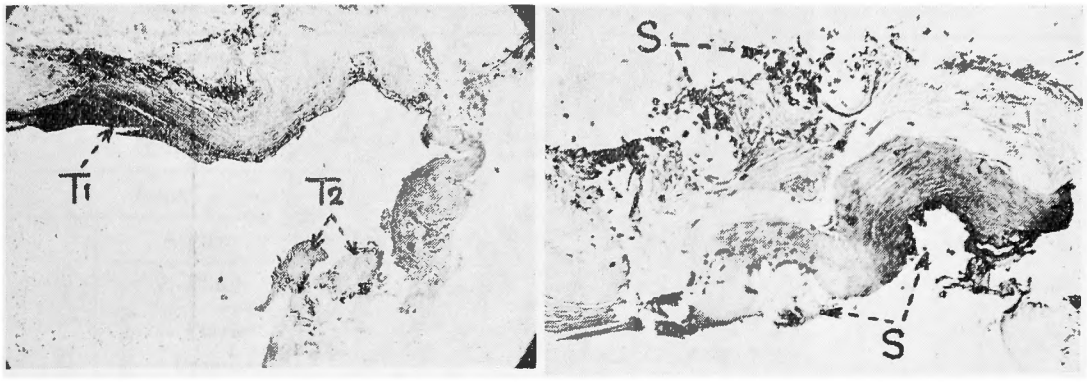

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Fig. 1.—a) Microscopic appearance of the portion of anastomosis between the left subclavian and pulmonary artery showing a patency of the channel. T_1 and T_2 respectively shows a clot attached to the wall of the vessel due to injury of the intima and those formed in the agonal stage. b) Microscopic appearance of the same portion. There are no clots attached to the suture (S).

Microscopic examination of the specimens was performed. The surgically created channel was patent at the portion of anastomosis (Fig. 1), but in the distal segment from here partially obstructed by thrombus attributable to hemostasis (Fig. 2). Intense pulmonary hemorrhage and edema due to congestion, and desquamation of bronchial epithelium were found (Fig. 3). These histological changes were more severe on the left side. In the right myocardium muscle fibers were hypertrophic, while in the left hypotrophic and partially degenerative.

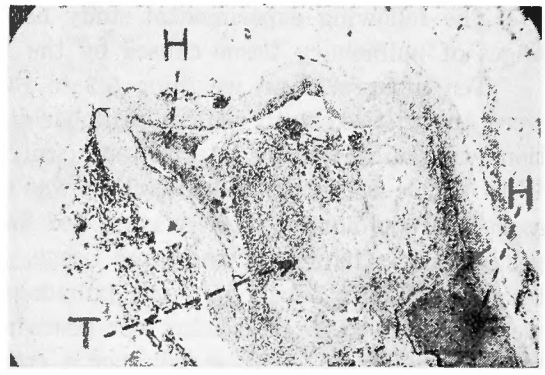
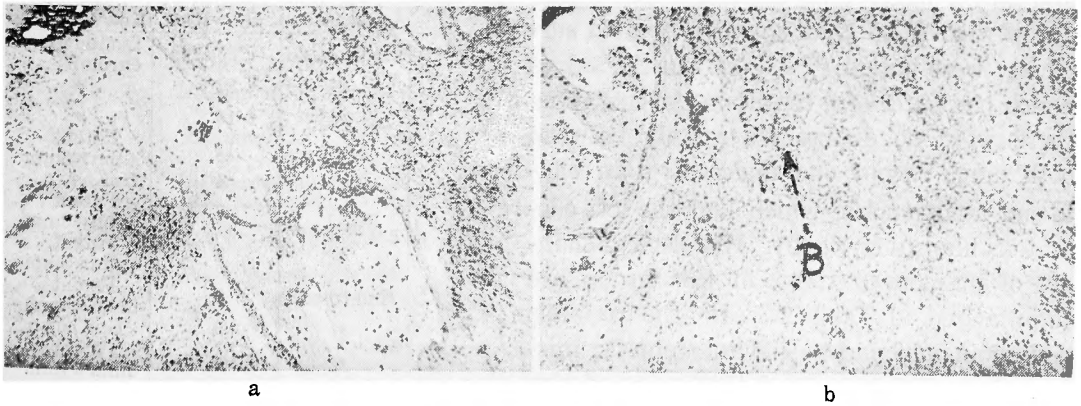


Fig. 2.—Microscopic appearance of the arterial segment distal to the anastomosis showing partial occlusion of the channel due to thrombus(T) and hemostasis (H) in the patent section.



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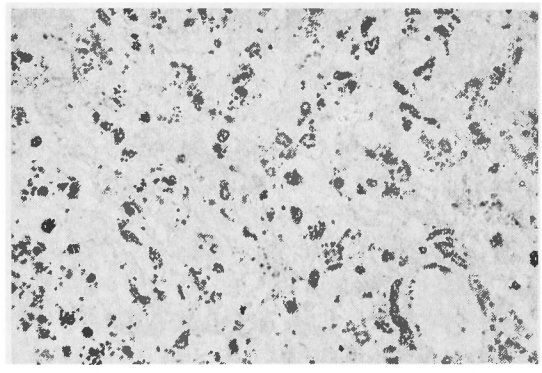

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Fig. 3.—Microscopic examination of the left lung revealed a) intense hemorrhage and edema due to congestion, and b) desquamation of bronchial epithelium (B). c) A high power photomicrograph of the same tissue.

EXPERIMENTAL STUDY

The following experimental study has been carried out to learn histological changes of pulmonary tissue caused by the Blalock operation.

Ten mongrel dogs, weighing 5.5 to 13 kg were used in all experiments. They were anesthetized with sodium pentobarbital (44 mg/kg intravenously). Lung inflation was maintained by intermittent positive pressure through an endotracheal tube. With sterile technique the left chest was entered through the third intercostal space, a piece of pulmonary tissue was excised for histological examination to compare with postoperative changes of the same tissue, and then the anastomsis of two manners between the left subclavian and pulmonary artery were performed. The animals were killed 7 to 29 days after the procedure. Both arteries were examined grossly at their junction to know whether a created channel was patent. In the animals with the successful result of operation, pieces of pulmonary tissue were excised from each lobe of both sides, and examined histologically.

All dogs survived operation. In 3 of 7 dogs undergoing an end-to-side anastomosis and 2 of 3 undergoing an end-to-end union, autopsy revealed that channels created surgically were patent (Table 1). In the 5 dogs which had successful results in the operation, there were no differences grossly between both lungs except one undergoing an end-to-end anastomosis, which had the left edematous lung (dog No. 8). Histological changes of pulmonary tissue in this group are summarized in Table 2. In the animals undergoing an end-to-side anastomosis, microscopic sections revealed thickening of alv-

Table 1. Experimental Results of the Blalock Operation

Dog No.	Type of Anastomosis	Length of Survival	State of Anastomosis
1	End-to-side	20days	Occluded by thrombus
2	〃	22	〃
3	〃	16	〃
4	〃	14	Patent 4mm×3mm
5	〃	4	UnKnown
6	〃	7	Patent 3mm×3mm
7	〃	7	Patent 4mm×3mm
8	End-to-end	9	Patent 5mm×4mm
9	〃	5	UnKnown
10	〃	8	Patent 4mm×4mm

Table 2. Histological Changes of Pulmonary Tissue befor and after Operation

Type of Anastomosis			End-to-side Anastomosis									End-to-end Anastomosis					
Dog No.			4			6			7			8			10		
Operation			befor	after		befor	after		befor	after		befor	after		befor	after	
Lung				Left	Right		Left	Right		Left	Right		Left	Right		Left	Right
Alveolus	Atypia		±	+	+	−	±	±	−	+	+	±	+	±	±	±	±
	Anomalous Content	Fluid	−	+	−	+	±	+	−	−	−	−	++	+	−	−	+
		Fibrin	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
		Desquamating Epithelium	−	+	+	−	−	+	−	−	−	−	++	+	−	−	−
		Erythrocytes	−	+	−	+	+	+	−	−	−	+	+++	+	−	−	±
		Leucocytes	−	+	−	−	−	−	−	−	−	−	−	−	−	−	−
		Lymphocytes	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
		Histiocytes	−	±	+	−	−	+	−	−	−	−	++	+	−	−	−
Alveolar Wall	Epithelium	Degeneration	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
		Desquamation	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−
	Thickening		+	++	+	+	++	+	−	++	++	±	+++	±	±	++	++
	Edema		−	++	+	+	+	+	−	++	++	−	++	++	−	+	+
	Hemorrhage		−	−	−	−	−	−	−	−	−	−	++	−	−	−	−
	Inflammation		−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	Capillaries		N	E	E	E	E	E	N	E	E	N	E	E	N	E	E
Bronchus	Anomalaus Content		−	+	+	−	+	−	−	+	+	−	++	−	−	+	+
	Epithelium	Degeneration	−	−	−	−	−	−	−	−	−	−	−	−	−	+	+
		Desquamation	−	−	−	−	±	−	−	+	+	−	+	−	−	+	+
		Anomalous Arrangement	−	−	−	−	±	−	−	+	+	−	+	+	−	±	±
		Proliferation	+	+	+	+	+	+	+	++	++	−	+	+	+	+	+
	Wall	Edema	+	+	+	+	+	+	+	+	+	−	+	−	+	−	+
		Inflammation	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	Surrounding Connective Tissue	Edema	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+
		Inflammation	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
		Degeneration	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
		Blood Vessels	N	E	E	E	E	E	N	E	E	N	E	E	N	N	N

Key : N……normal, E……enlarged

eolar walls due to capillary congestion, edema and cellular infiltration, and proliferation of bronchial epithelium, which were almost equal in degree in both lungs. While in the 1 of 2 in which the results of an end-to-end anastomosis was confirmed, in addition, severe hemorrhage into alveoli and their walls was detected only in the left lung (dog No. 8, Fig. 4).

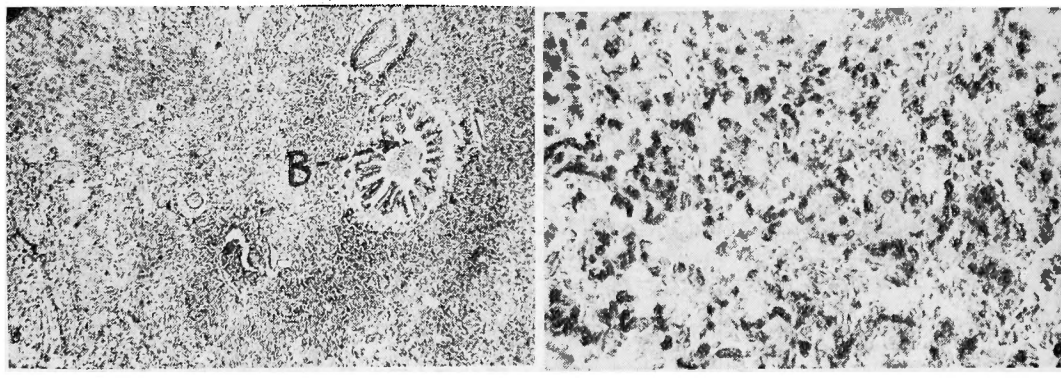

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Fig. 4.—a) Microscopic appearance of the left lung of dog No. 8 showing severe pulmonary hemorrhage. Intrabronchial hemorrhage is shown (B). b) A high power photomicrograph of the same tissue.

DISCUSSION

It is generally accepted that the results following an end-to-end anastomosis between the subclavian and pulmonary artery are almost as satisfactory as those following an end-to-side anastomosis. A good end-to-end anastomosis is preferable to an imperfectly performed end-to-side union. According to Blalock[3], the most frequent indications for this type are 1) a very small pulmonary artery (not more than two or three times the size of the subclavian artery) in which an end-to-side union would be less satisfactory, and 2) a short subclavian artery which it is difficult or impossible to approximate to the side of the pulmonary artery.

When an anastomosis between the proximal end of the left subclavian artery and the side of the left pulmonary artery is followed by a sharp angulation at the origin of the left subclavian artery, it is recommended by Holman[1] to divide completely the pulmonory artery proximal to the union after ligation. For the same reason, in our case, an end-to-end anastomosis had been done over again, and then followed by an appreciable improvement until her sudden death. Postmortem examination revealed that the cause of death was pulmonary hemorrhage and edema, especially in the left lung, due to excessive blood flow shunting. Likewise, in the 1 of 2 experimental animals in which the same type of anastomosis was performed, similar changes were proved on the side of the operation, while not in all 3 undergoing an end-to-side union. Consequently, there may be a fear of pulmanary hemorrhage and edema arising to the extent of a critical condition, when an end-to-end anastomosis is chosen as a curative means. It is supposed that a permanent improvement might be obtained in our case, if a good end-to-side union had been

performed.

SUMMARY

1) A case of Fallot's tetralogy has been reported, which expired suddenly, in spite of a temporary improvement, 44 hours after an end-to-end anastomosis between the proximal end of the left subclavian artery and the distal end of the left pulmonary artery.

2) Postmortem examination revealed that the cause of death was pulmonary hemorrhage and edema due to excessive blood flow on the side of the operation resulting from the surgical procedure.

3) The fact above mentioned was confirmed experimentally.

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Blalock氏手術に関する2,3の考察 (和文抄録)

山口医科大学外科学教室第1講座(主任 松本彰教授)

八牧力雄・川島貞昭

Fallot氏四徴症の1例(18才, ♀)に対しBlalock氏手術(左鎖骨下動脈と左肺動脈との端々吻合)を行つた所, 術直後動脈血酸素飽和度は74%より89%に増加し, 翌日はチアノーゼも消失したが, 44時間後に突然呼吸困難, 次いで意識を失い死亡した. 剖検により血管吻合部は開通し, うつ血による高度の肺出血と浮腫(手術側である左肺に強い)が死因であることを知つた.

10匹の犬に, 左側開胸で Blalock 氏手術を行い吻合部の開通を確認し得た端側吻合3例, 端々吻合2例について両肺の組織学的検査を行い, 端々吻合の1例に於て臨床例と同様, 著明な出血と浮腫を左側に認めた.

以上の事から Blalock 氏手術に於て1側の鎖骨下動脈と肺動脈を端々吻合した場合, 吻合部が閉鎖又は著しい狭窄を来せば生命の危険を生ずることは勿論であるが, 吻合部が開通していても容量以上の血液が肺に流入する場合には肺の出血と浮腫を来す恐れがある. 従つて止むを得ない場合のみ端々吻合を行うべきである.