OBSERVATIONS ON LIGATURE OF THE PATENT DUCTUS ARTERIOSUS

BY

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These remarks are based on the experience gained in 14 cases in which ligation of a patent ductus arteriosus has been performed. Twelve cases were uncomplicated by infection and in only two was endocarditis present. In 10 cases the patients were females, and the ages varied between 5 and 31 years. In the non-complicated cases the patients were all slightly stunted in growth and the majority were breathless on exertion, but only one showed any signs of cyanosis.

Method

The operative technique was similar in all cases. The approach was that described by Gross. The patient is placed on his back with a small sandbag under the left shoulder and upper part of chest, with arm extended above the head, thus allowing a slightly left lateral approach to the mediastinum. An incision is made along the second intercostal space, curving upwards to the axilla. It is found that splitting the pectoralis major rather than cutting it across gives sufficient access. The pleural cavity is opened through the second space and the second costal cartilage divided obliquely close to the sternum; in most cases the internal mammary artery is not interfered with, but if it is injured it can easily be ligatured. After the pleura is opened a single rib-spreader is introduced; the lung collapses away from the mediastinum and is lightly packed off with a gauze roll. In only one case were adhesions found between the lung and mediastinal pleura, and these were readily separated. On the mediastinal wall the phrenic nerve can be seen shining through the pleura, and an incision is made in the pleura parallel with the nerve and about an inch below it. There is a marked difference in the access to the operative area in children and adults: in the latter the arch of the aorta is much higher and is situated more deeply, thus increasing the difficulty of the operation; while in children the arch and pulmonary conus are immediately beneath the second space and the operative area is readily accessible.

After making the pleural incision it is advisable to clean the inner surface of the pleura on the lower side before increasing access to the mediastinum, as by doing so any small veins that may be present are separated, and these, falling away into the lax tissue, cause no further trouble or, if they have to be dealt with, can be picked up more readily and ligatured.

Blunt dissection backwards and upwards towards the arch of the aorta discloses the recurrent laryngeal nerve tightly winding round the aorta, and running more from right to left than is realized. This landmark immediately indicates the upper and posterior point of the ductus, and by working down to the pulmonary artery the left edge of the ductus is defined. The anterior and the right edge are more difficult to dissect out; at first sight there appears to be no space between the pulmonary artery and the inner surface of the arch of the aorta, but by slow blunt dissection a space is determined and the right border of the ductus defined. There seems to be considerable variation in the upward prolongation of the pericardium at this point, and in several cases fluid was present in the pericardium. When this occurs the pericardium, which is thin at this point, tends to bulge slightly into the operative area and obscure the view. In one case the pericardium was punctured and fluid oozed into the mediastinum throughout the operation.

The ductus itself, when defined, is very short and runs much more antero-posteriorly than one expects. Gentle traction with a finger on the pulmonary artery helps very considerably to define the ductus, allowing the operator more readily to free the posterior surface. This has to be done with great care by gently passing curved forceps behind it, as it is at this point that the ductus may be torn. In one of my cases this apparently happened towards the end of the dissection, but I was able to place the ligatures round the ductus, which stopped the bleeding.

When the ductus has been defined, pressure on it stops the very marked thrill of which the operator has been conscious throughout the proceeding. It is stated that the flow of blood through the ductus is from the aorta to the pulmonary artery; one would therefore expect that the amount of pressure to obliterate the ductus would be similar to that required to obliterate any artery. This, however, is not so: very light pressure, such as suffices to obliterate a vein on the back of the hand, is all that seems necessary, suggesting that the pressure in the ductus must be low and the blood flow may be from the pulmonary artery to the aorta, this being permitted by the eddy in the concavity of the arch. In one case the ductus was so thin that blood could be seen through the wall, and the flow appeared to be from the pulmonary artery to the aorta; but this point requires further investigation.

The ductus being freed, an aneurysm needle is passed and, contrary to Gross's views, I prefer to pass it from left to right. Care has to be taken that the recurrent laryngeal nerve is kept away from the ligatures, which is usually quite easy as the nerve is wrapped so closely round the aorta. No. 8 silk is used as ligature material, and it is waxed so that it runs easily. The moment the first ligature is tied the thrill disappears; in one case the ductus was so large in diameter and short in length that after tying the second ligature the first was found to be quite slack, and it had to be removed and another placed in position.

The incision in the mediastinal pleura is then sewn up and the lung re-expanded by positive pressure. A catgut suture is passed through the cut ends of the costal cartilage with a cutting needle—approximating the cut edges of the cartilage and preventing the unsightly appearance of an overlapping cartilage—after which the intercostal space is closed with sutures.

The rest of the wound is sutured with care, as unfortunately this particular incision tends to heal with an unsightly scar. In the last cases I have made the skin incision curve downwards almost to the nipple and then upwards to the anterior axillary line, and the subsequent scars have been less unsightly. The left upper arm is lightly bandaged to the side of the chest wall for 24 hours to prevent movement of the pectoralis major.

The convalescence of the uninfected cases was uneventful with the exception of one (Case 12). A radiograph on the third day usually showed the pressure of a small pneumothorax at the apex, and in some cases a little fluid. Both these were rapidly absorbed, and the patients were allowed to sit up in about 14 days; children were allowed up earlier.

Case 12 requires special note. This patient was an under-sized girl of 5½ who was in hospital for some little time before operation and had her adenoids removed about three weeks before the ductus was tied. The operation was uneventful and the child was allowed up on the sixth day. On the tenth day she had a temperature of 102°, which persisted without any apparent cause. A blood culture showed a pure growth of *Staph. aureus*. She was transferred to the penicillin ward of the Middlesex Hospital, and after treatment the temperature fell; subsequently it rose again, and a fresh blood culture produced a staphylococcus that was resistant to penicillin, and she eventually died. This case calls for a serious review of the procedure, but after careful consideration of all the facts I do not think that the operation can be held responsible; if anything, the argument for ligation is strengthened, as these patients with a patent ductus appear to be liable to start an endocarditis after an infection that is of little or no consequence in the normal person. The two infected patients both died. In one sulphonamide drugs had little or no effect; in the second they controlled the temperature for short periods only and eventually ceased to act.

It is too soon to say what the ultimate fate of these cases may be. One of the children is now taking up tap-dancing as a profession; the young male (Case 1) has been accepted for the Services. The others have lost their breathlessness on exertion, and the earlier ones that have recently been reviewed have improved in general health and physique.

It would seem that there is a case for the tying of an uncomplicated patent ductus. The risks attending such a persistent deformity have not yet been accurately assessed, but that there is a definite risk of infection which has a grave prognosis is unquestionable. Apart from this, however, the tying of the

ductus restores the patients' circulation to normal, breathlessness disappears, there is a marked improvement in their appearance, and a noticeable change for the better occurs in the mental condition. The last-named improvement is noticeable in the youngest patients, who from rather "solemn little owls" become bright and cheerful children.

Notes on Cases

Case 1.—Male aged 16. Admitted 2/12/41; discharged 23/5/42. Rejected by medical board on discovery of albuminuria and an abnormal heart. No symptoms. No evidence of circulatory inefficiency. Continuous murmur to left of sternum in pulmonary area. B.P. 140/75. Albuminuria was transient, and was never detected after the operation. A patent ductus was ligated on 14/3/42.

Case 2.—Girl aged 18. Admitted 5/5/42; discharged 12/7/42. Referred from medical board for morbus cordis. Harsh murmur and thrill throughout cardiac cycle in 2nd and 3rd left interspaces. B.P. 120/70. No evidence of circulatory failure. E.C.G. normal. Considered to be a case of uncomplicated patent ductus. Ligated on 2/6/42; uneventful convalescence.

Case 3.—Married woman aged 26. Admitted 15/6/42. Died. Known to have had congenital heart disease all her life. Activities always reduced. Pyrexial illness and increasing dyspnoea dating from tooth extraction two months before admission. Examination showed incipient circulatory failure; heart enlarged; murmur of patent ductus and loud systolic at apex. Early finger-clubbing. Positive blood culture of non-haemolytic streptococcus. Diagnosis: subacute bacterial endocarditis on a patent ductus; this was ligated on 19/6/42. Within a month after operation there was evidence of aortic valve involvement. Deterioration was rapid and death occurred two months after operation. Necropsy revealed extensive vegetation on the pulmonary artery and on the pulmonary valves.

Case 4.—Girl aged 10. Admitted 9/7/42; discharged 8/8/42. Complained of asthma since age of 4. Known to have had congenital heart disease since 6 months old. Pale and under-developed child. No symptoms or signs of inefficient circulation. Characteristic patent ductus murmur and thrill in 3rd left interspace. Ligation on 26/7/42.

Case 5.—Married woman aged 31. Admitted 28/8/42; discharged 31/10/42. Many years' history of dyspnoea on slight exertion, activities being considerably limited. Heart not enlarged; systolic thrill and continuous murmur in pulmonary area. B.P. 120/85. No circulatory failure. Radiograph revealed enlarged pulmonary artery. E.C.G. normal. The patent ductus was ligated on 29/9/42. Convalescence was uneventful.

Case 6.—Spinster aged 25. Admitted 9/9/42; discharged 23/10/42. Rejected from military service because of presence of patent ductus arteriosus. She had experienced rather more dyspnoea than is normal on exertion, but there were no other symptoms suggestive of her disease. The ductus was ligated on 24/9/42, after which the typical murmur entirely disappeared. Convalescence was uneventful.

Case 7.—Girl aged 9. Admitted 3/11/42; discharged 6/12/42. This girl had not experienced any abnormal symptoms, but was pale, slight, and asthenic, weighing only 3 st. 12 lb. A typical machinery type of murmur was heard in the pulmonary area together with a thrill. She had a low diastolic pressure. B.P. 120/55. An E.C.G. showed a normal curve, and a radiograph slight prominence of the pulmonary artery. The patent ductus was ligated on 19/11/42, after which all physical signs disappeared. Convalescence was uneventful.

Case 8.—Girl aged 12. Admitted 2/3/43; discharged 18/4/43. This patient complained of palpitations and breathlessness on mild exercise. The symptoms were relatively slight and she always felt well apart from breathlessness. At school she took part in swimming and physical training. She was well built. Her heart was normal in size. B.P. 135/70. Murmur was hardly a continuous one in the pulmonary area, being scarcely audible in diastole. No thrill was palpable. Ligation of the patent ductus was done on March 23, after which she had an uneventful convalescence, apart from a small hydropneumothorax. There were no abnormal physical signs in the heart.

Case 9.—Girl aged 21. This patient was admitted with a history of prolonged inactivity due to dyspnoea and exhaustion on exercise for at least seven years. She was well built, and examination showed no signs of heart failure. There was a loud continuous murmur in the pulmonary area accompanied by a thrill. No other signs of an additional congenital lesion were observed. The patent ductus was ligated on 6/4/43; the murmur was quite inaudible afterwards, and her convalescence was uneventful.

Case 10.—Boy aged 6½. This boy was quite fit on admission, but was small for his age. He had been followed up for some time on account of patent ductus arteriosus, but there was no evidence of disability from this. Examination revealed a characteristic to-

and-fro murmur, but there was no thrill over the 2nd left interspace. Ligation of the ductus was carried out on 13/8/43. His convalescence was completely uneventful, and the heart sounds were subsequently normal. This case is particularly noteworthy for the extremely small amount of disturbance which the operation caused. The boy was up and running about within a week.

Case 11.—Boy aged 5½. The patient had had dyspnoea on exertion for a period of about a year and failed to grow. He was an undeveloped child—height 43½ in., weight 35½ lb.—slow in speech but mentally normal. Pulse 110, regular rhythm; no clubbing; typical murmur running right through systole and diastole, best heard in pulmonary area; slight right-sided hypertrophy. Temperature normal; no evidence of infection. Radiograph showed very slight dilatation of pulmonary artery but no general enlargement. Ductus ligatured on 18/3/44: small ductus, about 1/4 in. The murmur had gone entirely after operation. On the evening of operation there was a small pneumothorax on the left side, and the next morning some surgical emphysema on the left side of the chest. These signs soon cleared up. Discharged on 30/3/44, symptom-free, left lung well re-expanded.

Case 12.—Girl aged 5½. Admitted 27/8/43 with an uncomplicated patent ductus arteriosus. Owing to the presence of some pharyngeal sepsis, adenoidectomy was performed on 24/9/43. After this she was very well, and was considered fit for operation. On 12/10/43 the ductus was ligated and found to be about 1/3 in. in diameter. Immediate post-operative convalescence was good, but on the ninth day she had sudden pyrexia, which subsequently proved to be due to a *Staph. aureus* septicaemia. This failed to respond to sulphathiazole and later to penicillin. She subsequently died on 24/12/43. No necropsy was performed.

Case 13.—Girl aged 20. Admitted 7/2/44. Was known to have had a patent ductus since shortly after birth. She had been well until about three weeks before admission, when she had an attack of "pneumonia." As her temperature did not settle she was seen by Dr. Morland, who diagnosed a septic infarct. On admission a blood culture gave a profuse growth of *Str. viridans*; after a blood transfusion and a course of sulphathiazole her temperature appeared more controlled. The ductus was ligated on 8/3/44, and after two days her temperature, which had been 103°, was again controlled by sulphonamide drugs. When these were discontinued the temperature rose again and she had a further infarct. Her condition then slowly got worse; she had infarcts in the kidneys and later in the brain.

Case 14.—Boy aged 7. Admitted 30/10/44. This boy had previously been seen, in consultation with Dr. Sheldon, when he was running a temperature thought to be due to endocarditis; but there was no growth on blood culture and his temperature reacted to a course of sulphonamides. He subsequently had his tonsils removed after a prophylactic course. It was decided that in view of his previous illness he should have his ductus ligatured; this was done on 4/11/44, and he was given a further course of sulphathiazole before and after operation. The ductus showed no evidence of old infection. He made an uneventful recovery, and was discharged on 21/11/44.

Dr. M. D. Nosworthy was the anaesthetist for all these cases. The anaesthetic was closed cyclopropane and ether. Blood-pressure readings and pulse rates were taken by him during the operation; no consistently demonstrable changes in pulse rate or blood pressure were recorded when the ductus was tied.

I wish to thank Dr. East, Dr. Sheldon, Dr. Maxwell, Dr. Cedric Shaw, Dr. Courtney Evans, and Dr. Andrew Morland, who have sent me the cases recorded; also Dr. Bridgen, who has collected most of the case notes.

BIBLIOGRAPHY

- Bourne, G. (1941). *Brit. Heart J.*, **3**, 228.
 —Keele, K. D., Tubbs, O. S., and Swain, R. H. A. (1941). *Lancet*, **2**, 444.
 Gross, R. E. (1939a). *New Engl. J. Med.*, **220**, 510.
 — (1939b). *Ann. Surg.*, **110**, 321.
 — (1940). *J. Amer. med. Ass.*, **115**, 1257.
 —Emerson, P. W., and Green, H. (1939). *Surgery*, **6**, 201.
 —and Hubbard, J. P. (1939). *J. Amer. med. Ass.*, **112**, 729.
 Hubbard, J. P., Emerson, P. W., and Green, H. (1939). *New Engl. J. Med.*, **221**, 481.
 Keele, K. D., and Tubbs, O. S. (1940). *St. Bari's Hosp. J. (War Bull.)*, **1**, 175.
 Tubbs, O. S. (1944). *Brit. J. Surg.*, **32**, 1.

The May issue of *The World's Children* (Save the Children Fund, 20, Gordon Square, W.C.1, 6d.) includes descriptions of various phases of child life—in China (by Jessie Booth), Nigeria (the Rev. E. A. Odusanwo), on the canals of Britain (by Ruth Layton), and in Cairo (Jeanne Marie Small). Dr. E. H. M. Milligan puts forward an idea for a "child international" to unite all child welfare organizations in Britain and the world, and the editor pleads for greater development of child education through the film, as was attempted in France before the war and is now being encouraged in the U.S.A.