Patent Ductus Arteriosus; Present Surgical Status*

JAMES W. NIXON, M.D., F.C.C.P.

San Antonio, Texas

After eight years of surgical treatment of patent ductus arteriosus the stage has been reached when a general survey of the progress made would seem warranted.

As early as 1907, Munro1 suggested the surgical ligation of a patent ductus arteriosus, and at necropsy demonstrated a possible operative approach. However no attempt to ligate a ductus in a living patient was reported in the literature until May 1938, when Graybiel, Strieder, and Boyer2 reported an attempt to obliterate a patent ductus in a patient with subacute bacterial endarteritis. Because recovery from this complication was extremely rare, they felt justified in taking this pioneer step; and although the patient died on the fourth postoperative day of acute dilatation of the stomach, the operation was definitely a step forward. According to Gross14 an earlier unsuccessful attempt to ligate a ductus had been made by O'Shaughnessy. The first successful ligation was performed by Gross and Hubbard6 in August 1938. Dolley10 stated that this success aided Dr. Jones and Dr. Bullock in obtaining parental consent for duct ligation in one of their patients, which operation was also successful. Then other parents, previously held back by untried surgical theory, readily consented to proved surgical fact. Since that time over three hundred cases of surgical closure have been reported in the literature.

Before weighing the results of surgical treatment of a patent ductus arteriosus, it is well to recall briefly the prognosis in such cases not treated by operation. In a review of the literature, Shapiro and Keys29 analyzed all the cases of patent ductus arteriosus in adults from which postmortem examinations have been reported. They stated that 80 per cent of such patients eventually succumb to their cardiac lesion. These patients who were alive at seventeen years of age averaged thirty-five years of age at death. At least 40 per cent of these patients died of subacute bacterial endarteritis, and most of the remainder died of congestive cardiac failure. Spontaneous rupture of the pulmonary artery or the ductus occurred in a few cases. The average age of the fifty-one patients of their own series was twenty-five years,

*Presented at the Twelfth Annual Meeting, American College of Chest Physicians, San Francisco, California, June 30, 1946.
and the oldest patient died at fifty-eight. Bullock, Jones, and Dolley\textsuperscript{11} reporting on eighty cases of patent ductus in patients over the age of three years proved by necropsy to have no other significant cardiac anomaly, presented somewhat similar statistics. Of this group 86 per cent died as the result of the congenital lesion. Fifty-three per cent died of bacterial endarteritis, twenty-three per cent died of congestive failure.

Since in the above mentioned series of untreated cases as much as 40 per cent or more died of bacterial endarteritis it is of special interest to study the progress made by surgical closure of the ductus in such cases. The first surgical cure of subacute bacterial endarteritis involving a patent ductus arteriosus was reported by Touroff and Vessel\textsuperscript{16} in 1940. In this and in subsequent reports,\textsuperscript{12,22,23,25} Touroff and his associates have contributed considerable information regarding such cases. Touroff states that in the early stages of infection, vegetations are likely to remain confined to the ductus and pulmonary artery, but in the latter stages of infection, or even in the early stages of severe infection, vegetations may spread to the cardiac valves or into the aorta. Continued presence of the infection increases edema and makes the ductus and the adjacent structures more friable. Because of these facts, the safety and effectiveness of the operation is greatly increased if surgical closure is effected as early as possible after infection is discovered. Shapiro and Keys\textsuperscript{29} reporting on 140 patients operated upon by a total of twenty-five surgical teams, stated that subacute bacterial endarteritis was present in thirty-three cases. Of these thirty-three, twenty operations resulted in apparent successful cure. Five patients died on the operating table as the result of hemorrhage, and in eight instances the fever persisted in spite of the ligation of the duct. In one of the cases\textsuperscript{30} in our series the streptococcus viridans disappeared from the blood stream almost immediately following ligation of the ductus and the patient entirely recovered. To date, more than four years after operation, there has been no return of infection. Blalock\textsuperscript{36} reported on six operations on patients with streptococcus viridans. Four were successful and two died subsequent to discharge from the hospital. Of these two, the lumen of the ductus became reestablished in one. Ziegler\textsuperscript{38} reported the successful surgical cure of an unusual subacute bacterial endarteritis by ligation in a patient with patent ductus arteriosus complicated by the presence of a patent interventricular septal defect and an anomalous left vena cava. Twenty-six (63 per cent) of these forty-one operations on cases associated with bacterial infection were successful. As is generally known, the mortality rate of untreated cases of subacute bacterial endarteritis is approximately 100 per
cent. Although in some cases of infection encouraging results have been obtained recently by large doses of penicillin,\textsuperscript{39} chemical therapy alone has not proved effective in cases where the bacterial infection is superimposed on a patent ductus. It is still too early to make a positive statement regarding the permanency of the cure effected by surgical closure of the ductus in such cases, but the results so far are definitely encouraging and, in the face of almost certain death without operation, it would seem that surgical closure should be strongly urged when it is known the infection is present. It is believed that improved operative technique gained through experience has already decreased the likelihood of operative failure in these cases. Johnson et. al.\textsuperscript{28} suggests an operative technique where the thin-walled ductus creates a hazard of injury to ductus wall, in cases with subacute bacterial endarteritis with implantation in the ductus. A suggested management of a torn ductus arteriosus is also given. It can not yet be stated that ligation of the ductus in non-infected cases will entirely remove the danger of subacute bacterial endarteritis as in two cases infection developed postoperatively. However, it is believed that ligation reduces the probability of this development. As observed by Touroff,\textsuperscript{23} the lungs play an important role in removing infective material from the circulating blood of humans and in cases of subacute bacterial endarteritis superimposed on patent ductus arteriosus, infective material enters the peripheral circulation at least in part, through the pulmonary circuit.

The question of suture materials has not yet been definitely established in the minds of surgeons as a whole, nor has the manner of ligation been entirely standardized, although the correct choice of material and method is very important to the success of the operation. Several types of ligatures have been used including linen, cotton, braided silk, and cellophane. Cellophane, alone, has not been favored as it might bring about partial stenosis of the pulmonary artery or the aorta. Wire, very popular in many operations, has not been used because of lack of resiliency, and the constant pulsating of the aorta might result in cutting through the ductus. The umbilical tape ligature of women silk 5/32 inch in breadth, advocated by Mont Reid,\textsuperscript{4} is probably the most frequently used. Several methods of closing the ductus have been used. The method of simple ligation with one ligature is not satisfactory as it leaves one end or the other of the duct open, allowing eddying which might not eliminate the roaring murmur, and would invite subacute streptococcus endocarditis. Also, the ligature may cut through the wall and allow the lumen to become patent again. Humphreys\textsuperscript{24} reported a case where ligation was made with a single heavy silk ligature and the patency became
reestablished, necessitating a second operation. A double ligature of umbilical tape was used at reoperation. Gross' originally used simple ligation, but later supplemented the use of woven silk ligature with the use of a ligature of cellophane, weight 300, of the unsurfaced type, placed over the silk ligatures. Another method used was that of a sclerosing fluid injected into a short segment of the ductus isolated by two ligatures. More recently Gross has reported a series of 87 cases in which complete surgical division and closure of the patent ductus arteriosus was successfully achieved. He believes this technique is more desirable where conditions indicate that complete division of the vessel can be accomplished. Touroff has stated that he found ductal ligation to be similarly effective to ductal division. We feel that cutting of the ductus is objectionable in that it adds somewhat to the gravity of operation with little, if any, benefit over ligation. Black has recommended placing one purse string suture flush with the pulmonary artery and one with the aorta, not tied too tightly for fear of cutting through the friable ductus, then two through-and-through mattress sutures of silk are placed and tied between the two purse string sutures. A ligature of umbilical tape is then tied over the mattress sutures of silk. This seems to be one of the most logical methods advocated, provided the ductus is not too short. He suggests that even if division and closure of ductus is the method used, the preliminary placing of purse string sutures at the extreme ends of the ductus would make the procedure less dangerous. In our experience, which is limited to eleven cases, we have used one of the methods first adopted. Two ligatures of braided silk are made, one flush with the aorta and one flush with the pulmonary artery. So far, there have been no bad effects and no reestablishment of the lumen of the ductus has been noted. This procedure is particularly applicable when the ductus is short and dissection and isolation is more difficult.

It is not felt that surgical closure of the patent ductus arteriosus should be indiscriminately advised in all cases, however the hazards of a patent ductus are sufficiently serious and the per cent of successful operations in experienced hands has increased enough that operation is advisable in probably the majority of cases. Gebauer and Nichol have expressed the belief that operation should be performed early because children withstand thoracic surgical procedures so much better than adults, because the operation is technically easier, and because the shorter the duration of patency, the less the degree of pulmonary dilatation, cardiac enlargement, vessel sclerosis, and the less severe the postoperative reaction.

It has long been recognised surgical closure of a patent ductus
would terminate fatally in cases where another abnormality of the heart is present which requires the open ductus as a compensatory mechanism. These cases are usually easily recognizable with careful examination. The function of the patent ductus in such cases was demonstrated recently by the interesting work of Blalock in case of partial stenosis of pulmonary artery in which he creates what might be called an artificial patent ductus arteriosus by anastomosing the innominate or subclavian artery to the pulmonary artery to divert the blood of the aorta to pulmonary artery, which is what occurs when ductus arteriosus remains patent. In this connection it would be interesting to note whether his cases will in time develop bacterial endarteritis. It would seem that large doses of penicillin should be administered immediately.

Ziegler observes that it is generally agreed that the absence of typical murmurs constitutes a contraindication to surgical intervention in cases of suspected patent ductus arteriosus, but since typical murmurs are absent in nearly a third of the cases and the incidence of subacute bacterial endarteritis ranges as high as 50 per cent, a decision in favor of surgery may be advised in such cases if the infectious agent is resistant to sulfonamides or penicillin, and of course, provided no other congenital defect is present which requires the patent ductus as a compensatory mechanism.

In our series of eleven cases, there were ten successful surgical ligations and one death from an associated interventricular defect. Of the ten successful operations, there were eight uncomplicated cases, one with streptococcus viridans infection, and one with an aneurysm of the pulmonary artery. It is interesting to note that although patent ductus arteriosus is not essentially a common vascular defect, two of the children of our series were first cousins with the same surname and approximately the same age.

At the end of five years we find general improvement in our patient's conditions. They are better developed and well nourished. One girl who had not menstruated, though beyond the normal age, has now started her regular periods.

COMMENT

Judging from our own experience and from a review of the cases reported in the literature, surgical closure of patent ductus arteriosus can be accepted as a successful means of treatment in a large number of cases. In view of the gratifying results in cases of bacterial endarteritis associated with patent ductus arteriosus, it is felt that surgical closure as soon as possible should be urged in such instances.
COMENTARIO

A juzgar por nuestra propia experiencia y por un repaso de los casos informados en la literatura, el cierre quirúrgico del ductus arteriosus abierto puede ser aceptado como un tratamiento satisfactorio en un gran número de casos. En vista de los resultados placenteros obtenidos en casos de endarteritis bacteriana asociada con ductus arteriosus abierto, se opina que en estos casos se debe urgar el cierre quirúrgico tan pronto como lo sea posible.

REFERENCES


