# ANALYSIS OF CASES OF PATENT DUCTUS ARTERIOSUS
## MAY, 1975 - DECEMBER 1980

THESIS

Submitted in Partial Fulfillment

For The Master's Degree ( General Surgery )

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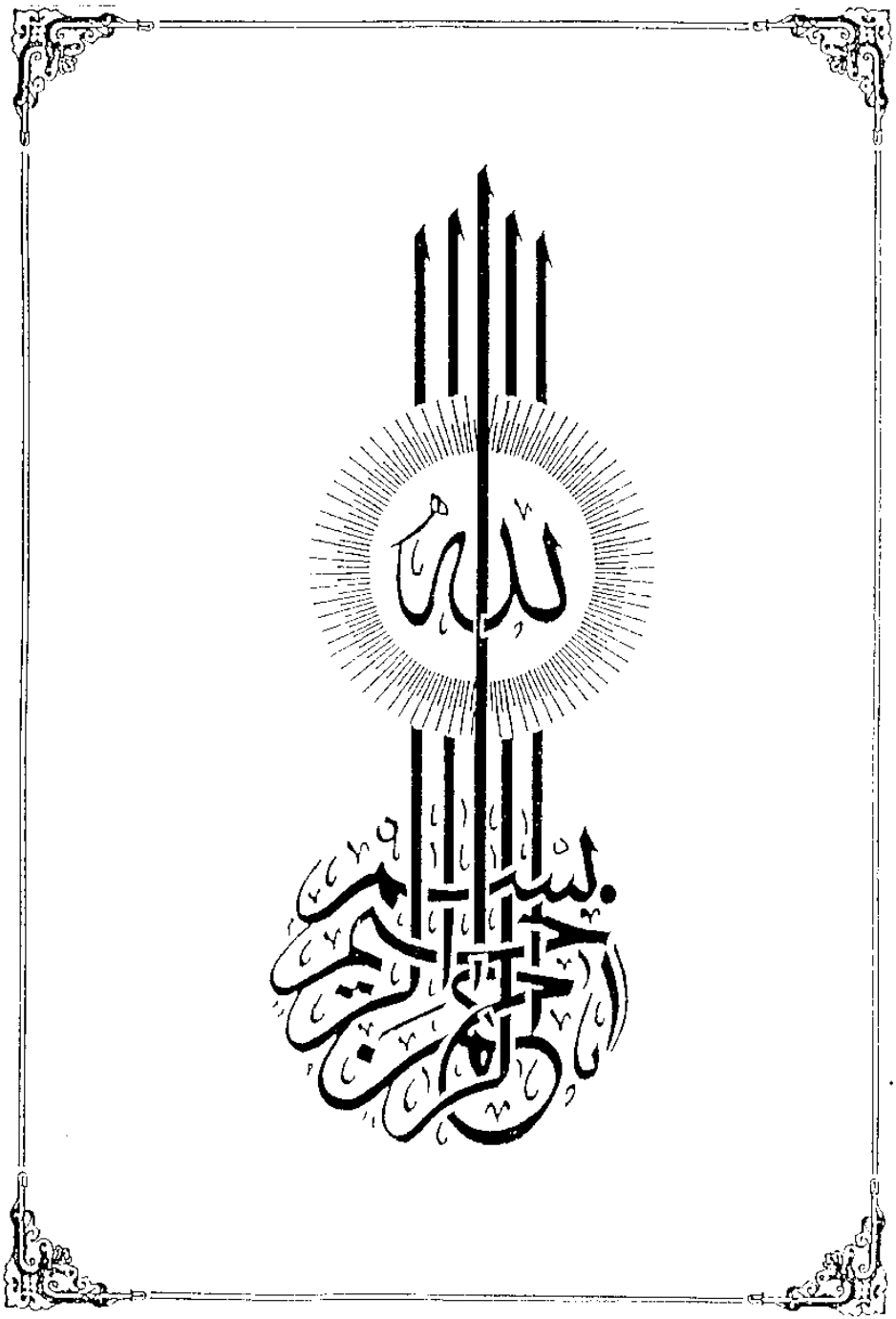
1982

TO MY PROFESSOR

DOCTOR HAMDY EL-SAYED



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## ACKNOWLEDGEMENTS

It is a great pleasure to express my deepest thanks and gratitude to Prof. Dr. Hamdy El Sayed; Head of the department of cardiothoracic surgery, for his suggestion and planning of this work, for his guidance, continuous advice and encouragement during his supervision of this work.

I am also grateful to Prof. Dr. Abdel Khalek Sarwat, Prof. of cardiothoracic surgery, who suggested the idea of this thesis. Really he was kind enough to offer me his advice and much of his valuable time. I will remain always remembering his excellant supervision, his helpful criticism, and highly appreciated efforts.

Lastly, I wish also to thank all the staff and colleagues in the department of cardiothoracic surgery and cardiology department for their help and cooperation.

# INTRODUCTION

# HISTORICAL INTRODUCTION

The first recorded mention of the term "Ductus Arteriosus" is attributed to Giulio Casare Aranizo in his De Humanis Foltre Libre published is 1595.

In 1900, Gibson was the first to give a precise description of the continuous murmur of the Patent Ductus Arteriosus. In 1925, Hólman analysed reports of 28 patients with PDA and described the probable direction of blood flow on the basis of the pathologic anatomy found at autopsy. He compared the ones with a left to right shunt through the ductus to persons with peripheral arteriovenous fistula.

Graybiel, Strieder, and Boyer in 1938 reported the first surgical attempt on the PDA. The patient had Subacute bacterial endocarditis, and technical difficulties at operation resulted in incomplete obliteration of the fistula by a series of plicating sutures. Death occured on the fourth postoperative day from vomiting and aspiration secondary to acute gastric dilatation.

Gross reported the first successful closure of a PDA in 1939. A single ligature was used by Gross who had subsequently modified his procedure to include multiple ligatures with injection of sclerosing solutions or wrapping with cellophane.

Because of the significant incidence of recanalization following the ligature technique (20%), Gross began dividing the ductus between haemostates and suturing both ends.

# REVIEW OF LITERATURE

## EMBRYOLOGY

Strictly speaking, PDA is not a form of congenital heart disease, but the abnormal persistance into postnatal life of a normal foetal structure.

The ductus arteriosus joins the root of the left pulmonary artery to the aorta just distal to the origin of the left subclavian artery; embryologically it is derived from the dorsal portion of the sixth branchial arch. During foetal life the ductus carries blood from the pulmonary artery to the aorta because of the high resistance to flow in the pulmonary vascular bed which is almost completely occluded because the lungs are unexpanded and unaerated.

Before the development of the pulmonary arteries, the fourth and sixth branchial arches are of equal size, indicating that they transmit equal blood flows. Once the pulmonary arteries contact the sixth arches, the arch segment between the original pulmonary arteries and the aortic sac becomes the pulmonary artery and its two main branches. The right sixth arch involutes, while the segment of the sixth arch that communicates between the pulmonary arterial tree and the left paired dorsal aorta remains patent; the ductus arteriosus.

As Rudolph et al and others showed, in the prenatal period equal amounts of blood pass through the pulmonary and aortic values. While most of the aortic blood is

distributed into the head region, most of the right ventricular output flows via the ductus into the descending aorta. During the first two weeks after birth, the pulmonary flow is distributed into the lungs and the ductus obliterates. During this process, active intimal proliferation is seen in the ductus, and the elastic layer in the media of the prenatal ductus is replaced by fibrotic connective tissue. The aortic isthmus expands and attains a calibre similar to that of the remaining aorta. The ductus is subsequently converted to a cord of fibrous connective tissue; the ligamentum arteriosum.

According to Daniel, anatomic closure of the ductus is complete by the age of two weeks in 35 % of newborn infants, by two months in about 90 % , and at one year in 99 %.

The Reasons for closure of the ductus arteriosus are not fully understood, but the oxygen tension of the arterial blood is clearly of great importance. In lambs and guinea pigs, increased oxygen in the foetal blood causes muscular contraction of the ductus, and Lind in 1955 and Burnard 1959 maintained that interference with respiration in newborn infants causes a functionally closed ductus to reopen. furthermore, it is well known that the incidence of PDA is significantly higher in babies born at high altitudes where the oxygen tension of the inspired air is reduced. Record and McKeown found that a history of foetal distress was commoner in children with PDA than in normal children.

This finding is also recorded by Sidney. Apart from low oxygen tension, the only other factor known to favour patency of the ductus is rubella suffered by the mother in first trimester of pregnancy. According to Eugenie and Monika, of 376 infants and children with biologically proved intrauterine rubella, 182 (48 %) had congenital heart disease. 37 of these had PDA.

According to Sidney and co-workers, a new concept regarding the mechanisms for persistence of the ductus, entails a reduced cholinergic innervation of the ductus and decreased ductal response to oxygen, resulting in a loss of vasoconstricting ability.

According to Moss and Robert, it is very likely that bradykinin, an endogenous polypeptide vasodilator, plays an important role in the acute circulatory adjustments at birth, including dilatation of the pulmonary vasculature and constriction of the ductus arteriosus and umblical artery.

In persistant ductus arteriosus the ductus does not obliterate; and instead of fibrous tissue, muscular elements replace the elastica in the media. Whether this is due to persistently high pulmonary resistance and significant flow through the ductus or to an inherited failure of the ductal tissue to retract has not yet been fully answered.

Studying a series of normal hearts from autopsies on 558 cases ranging in age from one day to one year, Christie found that the ductus was open two weeks after birth in 65 %, but this rapidly decreased so that only 2 % were open after 32 weeks and only 1 % at one year. Many of these were small openings which are functionally unimportant. Patency has been ascribed to interruption of the phase of muscular contraction.

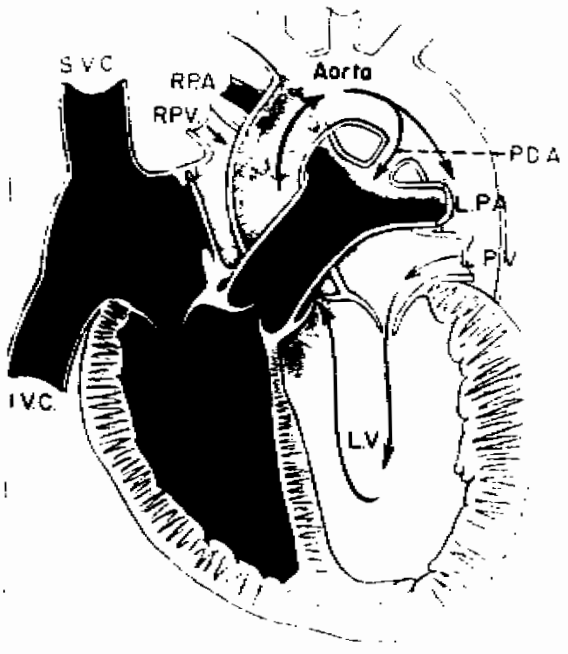
Michael A. Hyman et al studied the effect of acetyl salicylic acid on the ductus arteriosus in the fetal lambs in utero and concluded that the effects of prostaglandins $E_1$ & $E_2$ are more prominant at the low levels of $PO_2$ normally present in the fetus, and thus production of these prostaglandins in the ductus may be important in maintaining its patency during fetal life. They suggested that this dominance of prostaglandins $E_1$& $E_2$ activity, is responsible for maintenance of persistant patency of the ductus arteriosus in prematurely born human infants. They postulated that prostaglandins synthatase inhibition, therefore, may play an important role in therapeutic attempts at closing the ductus in these infants.

In support of the previous postulation, James et al reported six pre-term infants with PDA and respiratory distress in whom the PDAs were closed chemically by intravenous injection of indomethacin.

## ANATOMY AND PATHOLOGY

Patent ductus arteriosus is a communication between the pulmonary artery and aorta. It may present as : Isolated PDA, Aneurysm of PDA, PDA associated with intracardiac malformations, PDA associated with coarctation or interruption of the aortic arch and PDA as a component of a vascular ring.

Anatomically, PDA is a persistance of the normal communication between the pulmonary arterial system and the aorta in the foetus. The PDA exhibits considerable variation in width from a few millimeters to 2 or more centimeters. On the pulmonary side, the ductus arises from the cephaloposterior aspect of the commencement of left pulmonary artery. When viewing it from the front, the ductus appears to arise very close to cephaloposterior aspect of the bifurcation of the pulmonary artery. Since the pulmonary artery runs roughly in an anterposterior direction, the ductus is hidden in the frontal view by the main pulmonary artery. On the aortic side, the ductus is inserted into the lesser curvature at the level of the transition from the aortic arch to the descending aorta. It is usually found slightly distal to and opposite the origin of the left subclavian artery. Posteriorly, the ductus is related to the left main bronchus. In front of the ductus is found the left vagus nerve, and the




Schematic portrayal of the central circulation in patent arteriosus with left-to-right shunt. In this condition only two cardiac chambers, the left atrium and left ventricle, participate in the shunt.

recurrent laryngeal nerve encircles the ductus and ascends behind the aortic arch into the oesophago-tracheal groove medially.

The pulmonary end of the ductus is covered by a reflection of the pericardium, which appears as a small flat lappet that can be elevated off the ductus by sharp dissection. Behind the ductus is the region between the ductus and the left main bronchus; the pericardium adheres by fibrous tissue extension to the left main bronchus, the medial aspect of the aorta, and the left main pulmonary artery. This fibrous layer was described by Gross as a fibrous web.

While in prenatal life the media of the ductus includes elastica, this layer disappears after birth. When the ductus becomes a ligamentum arteriosum, the elastica is replaced by fibrous tissue. But when the ductus remains patent, the elastica is replaced by muscular elements.

Usually, in smaller children the wall of the ductus is relatively thicker and stronger. However, in patients with longstanding PDA as well as in some children particularly those with pulmonary hypertension the wall of the ductus is thin and friable and may be easily torn as a result of slight trauma. In cases associated with pulmonary hypertension and in older patients, moderate to heavy calcification may be found