

Review Article

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Surgical Closure of Isolated Patent Ductus Arteriosus in Neonates

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Abstract

The incidence of patent ductus arteriosus (PDA) is high in newborns. Although medical therapy is well defined, surgery is the mainstay of treatment for PDA. Surgery is challenging because these patients are so delicate that less invasive techniques with high attention are required. Careful evaluation of additional lesions, intervention time and choice of technique are important for these very high risk patients. We aimed to emphasize the important points of surgery of isolated PDA in newborns.

Keywords: Patent ductus arteriosus; Newborn; Surgery

Definition

Patent ductus arteriosus (PDA) is classically defined as an abnormal structure characterized by systemic-to-pulmonary shunting resulting from the persistence of a ductal structure between the descending aorta and pulmonary artery that exists during the intrauterine life. Serious problems occur in the early period due to an increase in the pulmonary blood flow caused by left-to-right shunting and its influences on the systemic circulation.

A ductus arteriosus is critically vital during intrauterine life; however, ductus arteriosus closes within a few days after birth with a decrease in pulmonary vascular pressure and contractions of smooth muscle cells in the wall of ductus arteriosus. The presence of PDA is considered if the closure of the ductus does not occur.

Causes

Patent ductus arteriosus is believed to be caused by the problems in early periods of fetal heart development, as is the case in most congenital cardiac diseases. However, it is not always possible to precisely establish the actual cause. Genetic and environmental factors may play a role [1,2].

Risk Factors

Prematurity: It is known that patent ductus arteriosus is four times more prevalent in preterm babies than in term babies [3]. The risk increases with decreasing gestational age at birth [4].

Gender: The risk is two times higher in girls than in boys [5].

Family History and Genetic Predisposition: It is known that the risk of having PDA is higher in babies with a family history of heart disease. Genetic disorders (e.g., Down syndrome) may also be related to PDA [6].

Accompanying Heart Diseases: The prevalence of PDA is higher in babies with a congenital heart disease.

Rubella Infection During Pregnancy: PDA is the most commonly observed cardiac problem in congenital rubella infection [7].

Hypoxia-Acidosis: The infants with perinatal exposure to respiratory distress, history of hypoxia, and infants developing acidosis have an increased PDA frequency. Furthermore, the prevalence of PDA is higher than average in infants born at high altitude [8].

Signs and Symptoms

The size of PDA and the magnitude of shunting are the main determinants for the speed of onset and severity of symptoms. A small PDA may remain asymptomatic, whereas a large PDA may cause problems as severe as heart failure. The infants often present with non-specific symptoms such as refusing to breast feed, irritability, growth and developmental retardation, rapid breathing, and tiring quickly. These patients are particularly prone to respiratory tract infections.

The symptoms of heart failure may be seen in the presence of a large PDA. The patients are also at risk of developing infective endocarditis.

Diagnosis

A typical cardiac murmur caused by a shunt between the aorta and pulmonary artery, and remarkable cardiac beats are the most common findings on physical examination.

A chest X-ray may reveal an enlarged cardiac silhouette and increased pulmonary vascularity. Electrocardiography may show the presence of an arrhythmia and cardiac block. Echocardiography is the most sensitive diagnostic test and is particularly useful in demonstrating the presence and size of PDA, the enlargement in cardiac chambers, and accompanying anomalies. Cardiac catheterization is not always required in an isolated PDA. Echocardiography may prove beneficial in the presence of accompanying cardiac anomalies or heart failure.

Medical Management

The prostaglandin inhibitors such as indomethacin and ibuprofen constitute the standard approach for the treatment of PDA. In our center, indomethacin is administered intravenously at a dose of 0.2 mg/kg in three doses with 12-hour intervals or ibuprofen is administered perorally at a dose of 10 mg/kg with 12-hour intervals. Interventional procedures or surgical management may be required if the use of medical agents is contraindicated, symptoms of severe heart failure occur, and prostaglandin inhibitors fail to close PDA [9,10]. Diuretics, digitalis-related drugs, or inotropic agents may be of use when heart failure develops. Coil occlusion or device-assisted closure of a PDA can be performed with low complication rates [11-13].

Surgical Management

The surgery for PDA can be performed in most centers with low complication rates [14-17]. The classical approach involves thoracotomy, but sternotomy or minimally invasive methods can also be used.

A median sternotomy may be required rarely in accompanying cardiac defects, calcific ductus, or a PDA with a very small and large base (window-type).

The classical approach involves left posterolateral thoracotomy, which can be performed as a bedside procedure in eligible centers [18]. We prefer bedside procedure in neonatal intensive care unit in very low-birth weight newborns ($< 2500\text{gr}$). An appropriately sized vascular line must be readily available. The patient is placed in the right lateral position with the left arm extended above the head. The scapula is elevated by passing through the latissimus dorsi and trapezius muscles following a small skin incision. The lung is retracted after entering the pleural space through the third or fourth intercostal space. The mediastinal pleura is opened to expose the descending aorta, left subclavian artery, aortic arch, and the ductus arteriosus. The ductus arteriosus must be temporarily occluded for testing purposes. An episode of

bradycardia or hypotension during testing may indicate a ductus-dependent circulation but may also avoid inadvertent closure of a vessel that is supposed to be the ductus arteriosus. The ductus can then be closed by placing a clip or suturing. After ligating the two ends of the ductus where possible, it is recommended that free ends of the ductus be divided in full thickness and then sutured. A placement of a drain into the thoracic cavity is often preferred.

Unnecessarily large thoracotomy may injure internal thoracic artery or intercostal vessels in the anterior and the thoracic duct in the posterior. Particular attention must be paid to not to damage the vagus nerve and recurrent laryngeal nerve while opening mediastinal pleura and dissecting the ductus arteriosus. It must also be kept in mind that the duct may be fragile. Possible complications are hemothorax, pneumothorax, nerve injury, chylothorax, residual ductus flow, or scoliosis and scapula alata that may develop in the long term secondary to thoracotomy. These complications are very rare even in bedside procedure.

In our center, between June 2010 and May 2020, 112 patients underwent surgical closure of isolated PDA. Forty-two of patients (37.5%) were newborn. In 16 newborn, bedside procedure was preferred. All operations were achieved with lateral thoracotomy and intrapleural route. We did not prefer extrapleural approach because opening the pleura facilitates surgery with no remarkable complications. There was no morbidity or mortality related to surgery but 6 patients (5.35%) died because of non-cardiac problems such as infection, renal failure or genetic disorders in newborn period.

Conclusion

An isolated PDA is a severe problem in the neonatal period, particularly affecting preterm infants. Spontaneous closure can be expected after diagnosis, but medical therapy offers a high success rate, particularly in symptomatic patients. Interventional methods or surgery must be planned without further delay in patients in whom medical therapy is contraindicated or when the patient does not respond to medical therapy or manifests symptoms of heart failure.

Surgical closure of an isolated PDA can be performed in the operating room or as a bedside procedure. Left posterolateral thoracotomy is the most widely performed classical method. The rate of surgical complications is extremely low.

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