

Surgical management of patent ductus arteriosus

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Abstract

Surgical ligation of patent ductus arteriosus can be performed safely by following standard steps of operation. Familiarity of the anatomical landmarks and simple precautions result in high degree of safety. The technique of surgical ligation varies with the age of the patient. Surgical ligation of ductus is associated with well-recognized complications, although they occur only in a small number of patients.

KEYWORDS

complications, operation, patent ductus arteriosus

1 | INTRODUCTION

A patent ductus arteriosus (PDA) is an abnormal persistence of the fetal ductus arteriosus in the postnatal period.¹ Embryologically, it represents the persistence of the distal portion of the left sixth aortic arch.² The PDA is usually a left-sided structure arising from the junction of the aortic isthmus with the proximal descending aorta and ending at the origin of the left pulmonary artery. In case of right aortic arch, the position of the PDA can vary widely.³ Depending on its size, a PDA can cause congestive cardiac failure, pulmonary hypertension, or even endocarditis. A large PDA in the neonate or preterm infant can result in diastolic steal of blood from the coronary and splanchnic beds resulting in acute renal failure or necrotizing enterocolitis.⁴ The pulmonary over circulation also results in increased ventilatory requirements.

1.1 | Diagnostic studies

Chest x-ray usually demonstrates pulmonary plethora with an enlarged left heart. Echocardiography is usually diagnostic of PDA. MRI or contrast CT is useful when the aortic arch is abnormal and the PDA is in atypical location. Cardiac catheterization is indicated in the older child with large PDA to assess pulmonary vascular resistance.

1.2 | Indications for intervention

Diagnosis of PDA itself is usually an indication for intervention unless it is very tiny. A large ductus can cause pulmonary over circulation and cardiac failure. A moderate-sized ductus can cause pulmonary

hypertension in the long run. A small-sized ductus can develop endocarditis. Surgical intervention is sought when ductus is refractory to medical therapy with indomethacin in the first few weeks or coil or device closure is not possible in the catheterization lab.⁵

1.3 | Contraindications for closure of PDA

There are several contraindications for closure of PDA which include

- Severe pulmonary vascular disease.
- Pulmonary artery hypoplasia.
- Pulmonary atresia.
- Tricuspid atresia.
- Transposition of the great arteries.
- Aortic valve atresia.
- Mitral valve atresia with hypoplastic left ventricle.
- Severe coarctation of the aorta.

1.4 | Surgical technique of PDA closure in the neonate

Dr. Robert Gross did the first successful closure of PDA in 1938 at Children's Hospital of Boston.⁶ The standard technique of closure of ductus in a neonate is described here. The patient is placed in a right lateral decubitus position. A roll is placed beneath the axilla. The left arm is placed in an abducted position. The left chest is prepped and draped. The operation begins with the placement of a limited skin incision over the posterolateral aspect of the left chest

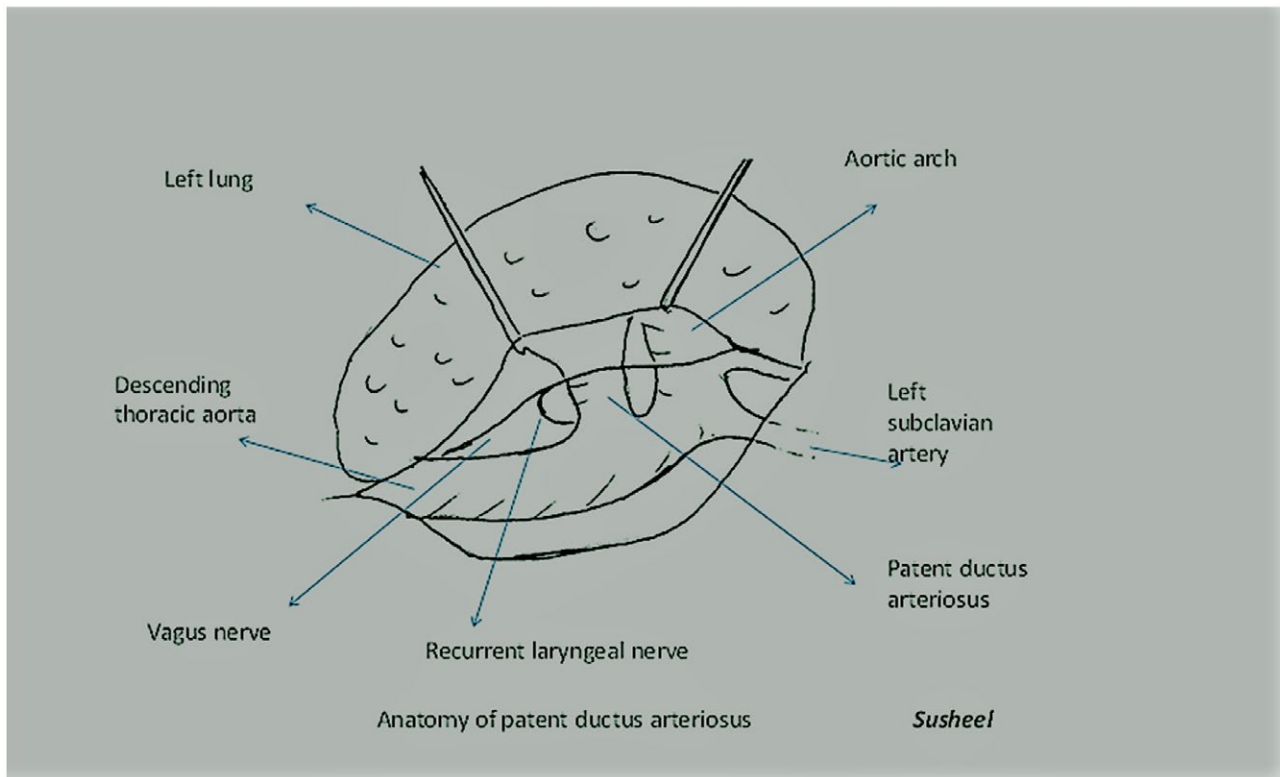


FIGURE 1 Relevant anatomy for dissection of patent ductus arteriosus

just below and parallel to the inferior border of the scapula. The latissimus dorsi and the posterior portion of the serratus anterior muscle are cut along the incision. The ribs are counted accurately to enter the third or fourth intercostal space. The intercostal muscle is detached along the superior border of the fourth or the fifth rib. Care is taken to avoid injury to the lung while entering the space. A rib spreader is used to open up the space. The left lung is retracted anteriorly to expose the descending aorta. The mediastinal pleura over the descending aorta are opened. The superior intercostal vein is either ligated or cauterized. The medial edge of the pleura is dissected anteriorly to expose the ductus. The vagus nerve and the recurrent laryngeal nerve can be seen coursing over the ductus. Care should be taken to avoid injury to the nerve or the ductus itself. The anatomy of the aortic arch, the left subclavian artery, and the ductus should be well demonstrated (Figure 1). Meticulous dissection is done along the superior and inferior borders of the ductus to create a space for the application of a steel clip. Following adequate dissection, the ductus is test clamped using vascular forceps. A rise in systolic and diastolic blood pressures, disappearance of murmur (can be auscultated via the endotracheal tube), and persistence of lower limb pulse are confirmatory of ductal occlusion. Following this, a medium-sized clip is placed over the aortic end of the ductus taking care to occlude the entire width of the ductus. Hemostasis is ensured, and the lung is allowed to reexpand. A small chest tube is placed. The chest is closed using pericostal absorbable sutures. The muscles are approximated in layers using a running absorbable suture and the skin is closed.

1.5 | Points to remember during surgical closure of PDA

1. Always identify the side of the aortic arch. The PDA is usually on the side of the aortic arch.
2. Always enter the proper intercostal space. When in doubt enter the higher space.
3. Never handle the ductus directly during dissection.
4. Always identify all the surrounding structures including the arch, the left subclavian artery, and the descending aorta to avoid inadvertent ligation of a wrong structure.
5. During test occlusion of PDA always confirm rise in systolic and diastolic blood pressures with persistence of pulse oximeter tracing in the lower limb.

1.6 | Variation in surgical technique for older patients

Modification of surgical techniques may be necessary depending upon the age of the patient.

- Beyond the neonatal period, the ductus is a firmer structure and can be divided between ligatures.
- In older children, the ductus can be divided between clamps and the ends closed using a running prolene suture.
- A subtraction technique may be necessary for surgical closure of hypertensive ductus.

- In adults, the ductus may be extremely calcified and may warrant a period of circulatory arrest for closure.

1.7 | Endoscopic closure of PDA

Video-assisted thoracoscopic surgery for closure of PDA was first described by Laborde in 1993.⁷ It has become popular in the last decade with the following advantages and disadvantages.

- Improved cosmetic appearance.
- Reduced pain and discomfort.
- Significant learning curve exists.
- Expensive.
- Higher incidence of residual ductal flow and recurrent laryngeal nerve injury.

1.8 | Risks of surgical closure of PDA

These include the following.

- Bleeding.
- Injury to recurrent laryngeal nerve.
- Rupture of lymphatics and chylous effusion.
- Inadvertent ligation of the descending aorta, arch, or left pulmonary artery.
- Residual ductus.
- Postligation syndrome.⁸

1.9 | Results of surgical closure of PDA

Mavroudis et al described their results of surgical management of PDA in 1994. A total of 1108 patients underwent operation for PDA over a 46-year period. The technique was predominantly ligation and division. No deaths or recurrence was reported.⁹ Niinikoski et al reported their results with very low birth infants who required ligation of PDA. The operative mortality was around 3%.¹⁰

CONFLICT OF INTEREST

The author has no conflict of interest and/or competing interest to report.


DISCLOSURE

No financial support was used for the conduct of this study.

AUTHOR CONTRIBUTION

Dr Thittamaranahalli Kariyappa Susheel Kumar was the sole author of this paper.

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REFERENCES

1. Oberhansli-Weiss I, Heymann MA, Rudolph AM, Melmon KL. The pattern and mechanisms of response to oxygen by the ductus arteriosus and umbilical artery. *Pediatr Res.* 1972;6:693-700.
2. Elzenga NJ. *The Ductus Arteriosus and Stenoses of the Adjacent Great Arteries.* Alblasterdam: Grafische Verzorging; 1986.
3. Santos MA, Moll JN, Drummond C, Araujo WB, Romao N, Reis NB. Development of the ductus arteriosus in right ventricular outflow tract obstruction. *Circulation.* 1980;62:818-822.
4. Wong SN, Lo RN, Hui PW. Abnormal renal and splanchnic arterial Doppler pattern in premature babies with symptomatic patent ductus arteriosus. *J Ultrasound Med.* 1990;9:125-130.
5. Peckham GJ, Miettinen OS, Ellison RC, et al. Clinical course to 1 year of age in premature infants with patent ductus arteriosus: results of a multicenter randomized trial of indomethacin. *J Pediatr.* 1984;105:285-291.
6. Gross RE, Hubbard JP. Surgical ligation of a patent ductus arteriosus: report of first successful case. *JAMA.* 1939;112:729-731.
7. Laborde F, Noirhomme P, Karam J, Batisse A, Bourel P, Saint MO. A new video-assisted thoracoscopic surgical technique for interruption of patent ductus arteriosus in infants and children. *J Thorac Cardiovasc Surg.* 1993;105:278-280.
8. Noori S, Kumar S. Pre-dicting post-ligation syndrome. *J Thorac Cardiovasc Surg.* 2017;154(6):2060-2061.
9. Mavroudis C, Backer CL, Gevitz M. Forty-six years of patent ductus arteriosus division at Children's Memorial Hospital of Chicago. Standards for comparison. *Ann Surg.* 1994;220:402-409.
10. Niinikoski H, Alanen M, Parvinen T, Aantaa R, Ekblad H, Kero P. Surgical closure of patent ductus arteriosus in very-low-birthweight infants. *Pediatr Surg Int.* 2001;17:338-341.

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